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ABSTRACT

Research literature concerning children's comprehension of pictures was compiled in order to clarify the role of textbook-type pictures in primary school children's learning of mathematics. The review is presented in eight sections: (1) psychological studies which investigated the role of imagery, comparing pictures with words, including (a) paired-associate tasks and (b) recall and/or recognition tasks; (2) sequence of studies investigating children's interpretation of progressively changing pictures; (3) characteristics of pictures; (4) children's picture perception; (5) children's picture preference; (6) children's ability to perceive depth in pictures; (7) relationship between pictures and reading skills of children from preschool through intermediate grades; and (8) the influence of pictures on the perception of mathematical relationships in primary school mathematics and on the solution of algebra word problems. In addition to a summary for each section, abstracts are provided for each study. (MS)

PMDC Technical Report
No. 5

Literature Review: Research on Children's Comprehension of Pictures

Patricia F. Campbell

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FOREWORD

Ed Begle recently remarked that curricular efforts during the 1960's taught us a great deal about how to teach better mathematics, but very little about how to teach mathematics better. The mathematician will, quite likely, agree with both parts of this statement. The layman, the parent, and the elementary school teacher, however, question the thesis that the "new math" was really better than the "old math." At best, the fruits of the mathematics curriculum "revolution" were not sweet. Many judge them to be bitter.

While some viewed the curricular changes of the 1960's to be "revolutionary," others disagreed. Thomas C. O'Brien of Southern Illinois University at Edwardsville recently wrote, "We have not made any fundamental change in school mathematics."[1] He cites Allendoerfer who suggested that a curriculum which heeds the ways in which young children learn mathematics is needed. Such a curriculum would be based on the understanding of children's thinking and learning. It is one thing, however, to recognize that a conceptual model for mathematics curriculum is sound and necessary and to ask that the child's thinking and learning processes be heeded; it is quite another to translate these ideas into a curriculum which can be used effectively by the ordinary elementary school teacher working in the ordinary elementary school classroom.

Moreover, to propose that children's thinking processes should serve as a basis for curriculum development is to presuppose that curriculum makers agree on what these processes are. Such is not the case, but even if it were, curriculum makers do not agree on the implications which the understanding of these thinking processes would have for curriculum development.

In the real world of today's elementary school classroom, where not much hope for drastic changes for the better can be foreseen, it appears that in order to build a realistic, yet sound basis for the mathematics curriculum, children's mathematical thinking must be studied intensively in their usual school habitat. Given an opportunity to think freely, children clearly display certain patterns of thought as they deal with ordinary mathematical situations encountered daily in their classroom. A videotaped record of the outward manifestations of a child's thinking, uninfluenced by any teaching on the part of the interviewer, provides a rich source for conjectures as to what this thinking is, what mental structures the child has developed, and how the child uses these structures when dealing with the ordinary concepts of arithmetic. In addition, an intensive analysis of this videotape generates some conjectures as to the possible sources of what adults view as children's "misconceptions" and about how the school environment (the teacher and the materials) "fights" the child's natural thought processes.

The Project for the Mathematical Development of Children (PMDC)[2] set out

[1] "Why Teach Mathematics?" The Elementary School Journal 73 (Feb. 1973), 258-68.

[2] PMDC is supported by the National Science Foundation, Grant No. PES 74-18106-A03.

to create a more extensive and reliable basis on which to build mathematics curriculum. Accordingly, the emphasis in the first phase is to try to understand the children's intellectual pursuits, specifically their attempts to acquire some basic mathematical skills and concepts.

The PMDC, in its initial phase, works with children in grades 1 and 2. These grades seem to comprise the crucial years for the development of bases for the future learning of mathematics, since key mathematical concepts begin to form at these grade levels. The children's mathematical development is studied by means of:

1. One-to-one videotaped interviews subsequently analyzed by various individuals.

2. Teaching experiments in which specific variables are observed in a group teaching setting with five to fourteen children.

3. Intensive observations of children in their regular classroom setting.

4. Studies designed to investigate intensively the effect of a particular variable or medium on communicating mathematics to young children.

5. Formal testing, both group and one-to-one, designed to provide further insights into young children's mathematical knowledge.

The PMDC staff and the Advisory Board wish to report the Project's activities and findings to all who are interested in mathematical education. One means for accomplishing this is the PMDC publication program.

Many individuals contributed to the activities of PMDC. Its Advisory Board members are: Edward Begle, Edgar Edwards, Walter Dick, Renee Henry, John LeBlanc, Gerald Rising, Charles Smock, Stephen Willoughby and Lauren Woodby. The principal investigators are: Merlyn Behr, Tom Denmark, Stanley Erlwanger, Janice Flake, Larry Hatfield, William McKillip, Eugene D. Nichols, Leonard Pikaart, Leslie Steffe, and the Evaluator, Ray Carry. A special recognition for this publication is given to the PMDC Publications Committee, consisting of Merlyn Behr (Chairman), Thomas Cooney and Tom Denmark.

Eugene D. Nichols
Director of PMDC

PREFACE

This publication is a review of literature written while the author was a graduate assistant for the Project for the Mathematical Development of Children. This research of literature concerning children's comprehension of pictures was undertaken in order to clarify the role of textbook-type pictures in primary school children's learning of mathematics.

Thanks are due to the Project administrative assistant, Janelle Hardy, for coordinating the technical aspects of the preparation of the report, to Maria Pitner for editing the manuscript, and to Julie Rhodes for the typing.

Introduction

An examination of current primary mathematics textbooks reveals that one of their means of communicating mathematical concepts to children is by pictures, in conjunction with written number sentences. The pictures are intended to aid the children in solving the related problems. Often the pictures themselves may supply sufficient information, so as to provide an entire basis for the solution. For example, a dynamic picture may clearly suggest addition or subtraction and allow the child to determine the answer by simply counting the objects in the picture. The intent is that children make a transfer from the dynamic situation illustrated in the picture to the abstract number sentence accompanying the picture.

The National Science Foundation supported Project for the Mathematical Development of Children (PMDC) has produced videotape recordings of children interpreting mathematical concepts. Analysis of taped interviews recorded during 1974-76 has suggested that first graders offer varying interpretations of pictures depicting mathematical relationships and, at times, may become confused by the pictures. In order to clarify the role of textbook-type pictures in primary school children's learning of mathematics, this review of literature was undertaken.

Research regarding children's learning from pictures is generally indexed under the heading of perceptual learning in developmental psychology. In educational research, it is usually indexed under audio-visual materials, communication strategies, or instructional media. Few studies have directly investigated children's learning from pictures as it relates to the elementary school mathematics.

This review of literature is presented in eight sections. The first section presents a selected review of current psychological studies which investigated the role of imagery, comparing learning from pictures with learning from words. These studies dealt with (a) paired-associate tasks and (b) recall and/or recognition tasks. The results of a sequence of studies which investigated children's interpretation of progressively changing pictures are presented in the second section. The third section considers characteristics of pictures. Studies which investigated children's picture perception and preference are noted in sections four and five. Studies which investigated children's ability to perceive depth in static two-dimensional pictures are reviewed in section six. The seventh section considers the relationship between pictures and reading skills of preschool through intermediate children. The eighth and final section presents studies which investigated the influence of pictures upon the perception of mathematical relationships in primary school mathematics and upon the solution of high school algebra word problems.

I. The Role of Imagery

Much of the research in psychology concerning how people learn from pictures is focused upon comparisons with how people learn from words. Many of

these studies are based upon paired-associate or recall tasks. Other investigations have measured responses to pictures by eye movement (Mackworth & Bruner, 1970) or by "same-different" judgments within recognition or matching-to-sample tasks.

Paired-associate Tasks

In a paired-associate task, a collection of discrete item pairs is successively presented to the learner. The pairs are then removed and upon presentation of the first member of the pair (the stimulus term), the learner must recall or recognize the second member of the pair (the response term). The success of the learner is dependent upon the permanency of the association within the pairs (Levin, 1972).

With young children, much of the paired-associate research has centered around presenting the paired items as words, as pictures of the items, or as picture-word pairs, systematically varying the concreteness both between and within the pairs (Rohwer, 1970). Research has rather consistently shown that pictures are superior as stimulus items over words for both children and adults (Dilley & Paivio, 1968; Levie, 1973; Levin, 1974; Paivio & Yarmey, 1966). For example, Dilley and Paivio (1968) used a paired-associate task with 120 nursery school, kindergarten, and first grade children to investigate the efficacy of pictures and words as both stimulus and response items. They found that pictures significantly facilitated learning as stimulus items, but that pictures had a negative effect as response items.

In addition to experimental manipulation of the physical properties of the associated items, the mediational link between the associated items has been investigated. This mediation may be provided by verbal elaboration, where a verb or sentence is given to relate the items within the pair, or by pictorial elaboration, where a picture is presented depicting the interaction of the items within the pair. Variables such as the meaningfulness or appropriateness of the mediation structure imposed on the items (Rohwer, 1966; Rohwer & Levin, 1968), the presentation mode of the pictures (Everston & Wicker, 1974), and the systematic variation of verbal and pictorial elaboration (Odom & Nesbitt, 1974) have all been investigated.

It has been noted by some researchers that there may be a developmental trend in the effectiveness of the two modes of elaboration; verbal elaboration appears relatively more effective with preschool children but loses its advantage as the subjects increase in age and develop the ability to utilize imposed pictorial elaborations (Milgram, 1967; Reese, 1970; Rohwer, 1970). However, the imposed pictorial elaboration did facilitate learning with the preschool subjects when compared to no mediation. Reese (1970) has suggested several plausible explanations of the relative superiority of older children over younger children in pictorial learning. One rationale suggested is that the preschool child does not "read" the picture in such a way as to infer a relationship between the depicted items. For example, as adult may relate a pictorial elaboration as "the spoon is holding a candle," whereas, assuming that a child in fact labels the items, it may be as "a spoon and a candle." Rohwer (1970), on the other hand hypothesized that verbal modes of representation develop earlier than pictorial modes. Other researchers have refuted that hypothesis

(Bruner, Olver, Greenfield, Hormsby, Kenney, Maccoby, Modiano, Masher, Olson, Patter, Reich & Sonstroem, 1966). Still another interpretation has been investigated (Cramer, 1975; Lynch & Rohwer, 1972). These researchers have asserted that older children are more capable of attaching a verbal label to a pictorial stimulus and this double encoding, both verbal and visual, increases the likelihood of subsequent recall. All of these explanations are further complicated by recent research results which have failed to replicate a developmental trend in the ability to benefit from imposed pictorial elaboration (Everston & Wicker, 1974; Odom & Nesbitt, 1974).

In all of the paired-associate tasks with mediation referred to above, the mediating link was imposed upon the subject by the experimenter; that is, either a picture depicting interaction of the paired items or a verbal statement describing the interaction was provided by the experimenter. Other researchers have investigated associative learning when the subjects are instructed to generate their own sentences or visual images, relating the items in the pair in some way. Some generalizations concerning the development of visual imagery strategy may be suggested by this literature.

While young children are able to use an imposed elaboration effectively (Levin, 1974; Odom & Nesbitt, 1974; Reese, 1970), they are usually unsuccessful when requested to generate an organizational strategy on their own (Jensen & Rohwer, 1965; Levin, 1974; Wolff & Levin, 1972). This distinction seems to be greater for visual imagery than for generating sentences to associate items in a pair. Although a developmental study conducted by Jensen & Rohwer (1965) determined that kindergarten children did not benefit from induced sentence instructions as did second graders, a later study noted that 4 and 5 year olds had little difficulty producing sentences and, as shown by their performance on paired-associate tasks, were able to utilize these sentences effectively (McCabe, Levin & Wolff, 1974). Similarly, Montague (1970) reported that her sample of inner-city first graders was able to benefit from induced sentence instructions to the extent that their scores on paired-associative tasks did not differ significantly from the scores of subjects in the imposed pictorial or verbal conditions. However, the first graders were not able to benefit from an induced visual imagery strategy. By the age of 7 or 8, most children are able to benefit from imagery instructions (Danner & Taylor, 1973; Jensen & Rohwer, 1965; Levin, Davidson, Wolff & Citron, 1973; Wolff & Levin, 1972). A study by Varley, Levin, Severson, and Wolff (1974) indicated that even though children between the ages of 5 and 7 do not appear to be able to utilize induced imagery instructions, they can acquire this skill with appropriate instruction involving manipulations of concrete materials. In summary, as stated by Levin (1972), evidence suggests that:

> The emergence of subject-generated sentence mnemonics as facilitative learning strategies may closely approximate the emergence of subject-generated dynamic imagery, the former preceeding the latter (p. 5).

Recall and/or Recognition Tasks

Other studies concerning the role of imagery in learning have considered the differences between pictures and words as stimuli for memory retention tasks which do not require associative skills. In these studies, subjects are

shown a sequence of items (presented as either pictures or objects or as written words and, after a specified time span, the subjects are required either to identify the stimulus items from a larger collection of pictures and/or words (recognition) or to name the stimulus items when the stimuli are no longer present (recall).

Studies using adult subjects have revealed that people possess an extraordinary recognition memory for pictures, with a somewhat lessened capacity for recognition of words. For example, Shepard (1967) exposed adult subjects to three memory recognition tasks, each consisting of approximately 600 stimuli. Previously exposed words and sentences were recognized with 89% accuracy; previously exposed words and sentences were recognized with 97% accuracy. Care must be taken in interpreting these data since the word and picture lists were not identical in either length or content. However, subsequent research with adults using simple line drawings and words of familiar objects has supported the superiority of pictorial representation over verbal labels in recognition memory (Jenkins, Neale & Deno, 1967; Paivio & Caspo, 1969).

Comparison of recall of verbal and pictorial stimuli is confounded by the fact that the recall response usually requires the subject to state or write the word identifying the stimulus. However, reports of recall studies utilizing adult subjects still tend to indicate that more pictures than words are recalled (Lieberman & Culpepper, 1965).

Thirty-two preschool children identified 44 pictorial stimulus items out of a field of 100 items with 98% accuracy on an immediate recognition task. One week later the subjects viewed 36 of the original 100 pictures in a field of 72 pictures; of these 12 were original distractor items. Accuracy level in identifying the original distractors was 73% (Brown & Scott, 1971). In a study with first graders, Entwisle and Huggins (1973) observed similar results and concluded that "young children can apparently process and retain a rather large amount of complex iconic information unrelated in any way to their ongoing activities" (p. 393). Young children have also been reported as being more successful on recognition items involving pictorial stimuli than with corresponding written word items (Corsini, Jacobs & Leonard, 1969).

Jenkins, Stack, and Deno (1969) administered both a memory recognition task and a memory recall task involving 17 stimulus items to 116 second grade students. They found that the stimulus mode (picture or word) had no significant effect on the recall task, but significantly more pictures than words were correctly identified in the recognition task. This investigation serves to underscore the difference between recall and recognition tasks; success or failure in one form of memory retention need not predict performance on the other form.

In an effort to further explore the nature of children's retention of pictorial stimuli, some researchers have begun to investigate recognition of reversals or orientation changes where the field distractor items are preceptually similar to the initial stimuli. Even preschool children have been found to be very successful in detecting orientation changes of items on matching-to-sample tasks (Stein & Mandler, 1975; Wohlwill & Weiner, 1964). In other stud-

ies, children were found to be capable of recognizing left-right reversals of pictures, particularly if the reversal required a location change as well as an orientation change (Mandler & Stein, 1974, 1975).

Brown and Campione (1972) presented 51 preschoolers with one of three recognition tasks (varying the length of retention period) involving pictures of people or animals. These tasks required the children not only to identify whether they had seen a picture of the character before, but also whether the character had been depicted "doing the same thing" in the stimulus item. The accuracy of correctly identifying distractor items was consistently high for all retention periods, whereas the ability to recognize stimulus items decreased significantly with longer retention periods. The probability of correctly classifying a character as engaged in an identical task decreased significantly over time; however, there was not significant change over time in the ability to correctly classify an item as being similar.

Brown, A.L., & Campione, J.C. Recognition memory for perceptually similar pictures in preschool children. Journal of Experimental Psychology, 1972, 95, 55-62.

Brown and Campione report on three studies which investigated preschool children's (3-5.5 years) ability to recognize minor changes in pictures depicting human figures or animals. The distractor items varied from the original stimuli only in terms of type of activity engaged in by the central character of the picture.

In the first study, the 15 subjects were told in the original viewing that in later pictures the characters may be "doing something different." The testing phase came immediately after viewing the stimuli; the subjects were asked to identify whether they had seen the character before and whether it was shown engaged in the activity. Accuracy in recognizing the figure and in classifying it as identical or similar was above 90%.

In the second study, 18 subjects viewed the stimulus pictures, but were not warned that the recognition pictures might depict the characters in other activities. The retention period before testing was either 2 hours, 1 day, or 7 days. For all three retention periods the accuracy of correctly identifying a picture as depicting new characters was at least 95%. The accuracy of identifying pictures which depicted the same characters as the stimuli significantly dropped with longer retention periods from 90% at 2 hours to 75% at 7 days. The ability to classify correctly a picture as portraying the same character in an identical activity decreased significantly over time from approximately 93% accuracy at 2 hours to about 68% accuracy at 7 days. There was no significant change over time in the subjects' ability to classify pictures as portraying the figures engaged in a similar, but not identical, situation.

The third study had a different format as the 18 subjects were shown pairs of pictures depicting the same central character during the testing phase. The subjects were asked to identify whether they had seen the character before and,

if so, which of the two poses was identical to the previous viewing. Again the retention periods were 2 hours, 1 day or 7 days. For all retention periods, the accuracy of correctly identifying a new figure was above 95%. The ability to correctly identify a picture as depicting the same character as the stimulus dropped significantly from 92% accuracy at 2 hours to 81% accuracy at 7 days. For all retention periods, the accuracy level for choosing the identical pose from the pair was at least 85%.

Brown, A.L., & Scott, M.S. Recognition memory for pictures in preschool children. Journal of Experimental Child Psychology, 1971, 11, 401-412.

This article is a report of two studies which investigated preschool children's (3-5.5 years) recognition memory. In the first study, 32 subjects viewed 100 pictures; 44 of these pictures were viewed twice during the presentation, 12 of these pictures were viewed once. Each subject was asked as he viewed each picture if he had seen it previously (immediate retention task). Accuracy in correctly identifying a repeated picture was 98% with less than 1% of the distractor pictures classified as being viewed previously. After a retention period of 1, 2, 7, or 28 days, the subjects viewed 72 pictures; 36 of these pictures were in the original collection of 100 pictures classified either as a distractor or as a repeated picture. The children indicated whether they had seen the pictures in the original collection of 100 pictures. Repeated pictures within the immediate retention tasks were identified with 94% accuracy within a 1, 2 or 7 day retention period, with 78% accuracy at 28 days. Distractor pictures within the immediate retention task were recognized with 84% accuracy at a 1 or 2 day retention period, 73% accuracy after 7 days, and 56% accuracy after 28 days.

In the second study, eight subjects viewed the same collection of 100 pictures used in the first study and were told simply to look carefully at the pictures. After a 7 day retention period, these subjects viewed the collection of 72 pictures. Repeated pictures within the original set of 100 pictures were identified with 78% accuracy; the original distractors were identified with 69% accuracy.

Bruner, J.S., Olver, R.R., Greenfield, P.M., Hornsby, J.R., Kenney, H.J., Maccoby, M., Modiano, N., Mosher, F.A., Olson, D.R., Patter, M.C., Reich, L.C. & Sonstroem, A.M. Studies in Cognitive Growth. New York: John Wiley, 1966.

This text is a collection of papers concerning cognitive growth which grew out of seminars and exchanges between Bruner, his students, and postdoctoral fellows. The first two chapters describe the rationale and theory behind the research represented in the remainder of the text, namely, particular evidence of cognitive growth (classification, perceptual recognition, equivalence, conservation, etc.). In these initial chapters Bruner discusses intellectual

growth and the ability to represent reality within an enactive, iconic, and symbolic levels. His characterization of cognitive growth asserts the development of pictorial forms of representation prior to verbal forms.

Corsini, D.A., Jacobus, K.A., & Leonard, S.D. Recognition memory of preschool children for pictures and words. Psychonomic Science, 1969, 16, 192-193.

Forty preschool children (4-6 years) viewed were assigned to either a word or a picture condition. The 100 item recognition list consisted of 48 test items (each occurring twice in the presentation) and 4 distractor items (occurring once in the presentation). The word and picture lists were identical in content. Subjects viewed the picture or word list individually with an investigator and, upon presentation of each picture or word, indicated whether the picture or word had been seen previously. Results indicated that significantly fewer errors occurred in the picture condition.

Cramer, P. Learning pictures and words: The role of implicit verbal labeling. Journal of Experimental Child Psychology, 1975, 19, 489-501.

This study was designed to investigate the hypothesis that older children more readily attach a verbal label to a pictorial stimulus and this combined verbal and visual labeling increases the likelihood of success on paired-associate or recognition tasks. Word pairs were selected such that if joined, a compound word resulted with a different meaning (e.g. cow, boy, cowboy; pen, knee, penny). Subjects who attached a verbal label may experience a false recognition of compound items whereas subjects who did not provide a verbal label should not recognize the compound items on paired-associate tasks with a pictorial stimulus.

Second, fourth and sixth graders (144 subjects) viewed 16 item pairs (either 16 picture-picture, picture-word, word-word, or word-picture pairs). The students were then administered a recognition test which required the students to circle any drawing or word they had seen in the pairs. This test contained 16 stimulus items, 16 response items, 16 compound items, and 16 unrelated control items. Then the subjects were administered the traditional paired-associate task.

Analysis of the data from the recognition test revealed a significant effect due to item type with a grade x item type interaction. The stimulus and response items were identified more often than the compound items; the compound items were recognized more often than the control items. There was no significant difference between grade levels on the correct circling of stimulus and response items or the incorrect circling of control items. However, second graders made significantly fewer incorrect circlings of the compound items than did the fourth or sixth graders. On the paired-associate task, the second graders did significantly poorer than the fourth or sixth graders.

Danner, F.W., & Taylor, A.M. Integrated pictures and relational imagery training in children's learning. Journal of Experimental Child Psychology, 1973, 16, 47-54.

Sixty children (first, third, and sixth graders) were assigned to one of four conditions for a paired-associate task. The students viewed 18 line drawings, each of which depicted a pair of items. Half of the students viewed drawings depicting the items integrated by action and/or spatial position; the remaining students viewed pictures which presented the items side-by-side. Half of the students in each picture-type received training in relational imagery using three of the line drawings; testing using a recall procedure utilized the remaining 15 pictures. Results indicated that groups which received imagery training and/or viewed integrated pictures performed significantly better at all grade levels. Analysis of the scores of the group who viewed non-integrated pictures without imagery training indicated a significant increase in score with age; this was not so for the other experimental conditions.

Dilley, M.G., & Paivio, A. Pictures and words as stimulus and response items in paired-associate learning of young children. Journal of Experimental Child Psychology, 1968, 6, 231-40.

This study investigated the hypothesis that as stimulus items, pictures would facilitate learning, but would hinder learning when used as response items. One hundred twenty subjects aged from 44 to 91 months were presented with five picture-picture, picture-word, word-picture, or word-word pairs. The pictures were line drawings; the words were orally presented. Results indicated a significantly better performance by subjects in the picture-word category; pictures had a negative effect as response items. No effect due to age was noted.

Entwisle, D.R., & Huggins, W.H. Iconic memory in children. Child Development, 1973, 44, 392-394.

This article is a report of three studies of first graders' iconic memory as measured by a recognition task. In the first study, 23 first graders viewed 40 black and white slides depicting landscapes or urban scenes. Approximately 2.5 hours later the children viewed 40 pairs of slides on two screens and indicated which of the two slides they had seen previously. The average correct identification was 31 slides; over 90% of the children correctly identified more than 20 of the slides. In a similar study using color slides, 30 first graders averaged 34.2 correct identification with 97% of the children recognizing more than 20 of the slides. A third study again presented 40 color slides to 29 first graders with a one week retention period before testing. In this case, an average of 31.9 slides was correctly identified with 86% of the students recognizing more than 20 of the stimulus slides.

Everston, C.M., & Wicker, F.W. Pictorial concreteness and mode of elaboration in children's learning. Journal of Experimental Child Psychology, 1974, 17, 264-270.

In order to investigate paired-associate learning as a function of age, mode of elaboration, and pictorial complexity, 120 subjects (aged 4 or 7 years) viewed 9 stimulus-response pairs. The pairs depicted either visual interaction within each pair or side-by-side portrayal of the items with an accompanying verbal elaboration relating the items. The items were presented via black and white drawings, color photographs, or concrete objects. Analysis indicated a significant effect due to age (older children performed better) and stimulus type (objects and photographs over line drawings). However, there was no significant interaction between age and stimulus complexity nor was there the expected developmental trend in the ability to utilize pictorial elaboration. Results indicated that the 4 year olds performed better with visual interaction items than with verbal elaboration, whereas no significant difference due to mode of elaboration was noted for the 7 year olds.

Jenkins, J.R., Neale, D.C., & Deno, S.L. Differential memory for picture and word stimuli. Journal of Educational Psychology, 1967, 58, 303-307.

In this study 120 college students were assigned to one of four recognition treatments: See stimulus pictures, recognize pictures; see stimulus pictures, recognize word labels of the pictures; see written words, recognize written words. The pictures were black and white line drawings. The subjects initially viewed 17 stimulus items as either drawings or written words. Then the subjects viewed 42 items (words or drawings) and indicated whether each item had been seen previously, had not been seen previously, or indecision as to whether the item had been seen previously. Results indicated that the picture-picture treatment yielded significantly better recognition of both stimulus items and distractor items than the word-word treatment. The picture-word treatment group correctly identified significantly more stimulus items than the word-picture treatment group.

Jenkins, J.R., Stack, W.B., & Deno, S.L. Children's recognition and recall of picture and word stimuli. AV Communication Review, 1969, 17, 265-271.

Both recognition and recall were tested in this study using 116 second graders classified as being in either high or low reading levels. Half of the subjects in each reading level viewed slide pictures of 17 common items; the remaining students saw slides naming the 17 items. Then each student viewed 41 slides and indicated whether or not they had seen the slide previously. For all the recall task, the subjects again viewed 17 word or picture slides; then the students were asked to write down the label of as many slides as they could remember.

Analysis of variance indicated no significant difference in the students' performance on the recall task between the picture and word conditions. Recall was significantly related to reading level. but no significant interaction between reading level and stimulus mode was noted. On the recognition task the scores of students who viewed picture stimuli were significantly higher than the recognition socres of children who viewed word stimuli. No effect due to reading level was noted. Identification of distractor items in the picture mode was also significantly higher than identification of distractor within the word format. Students who viewed a word were more likely to incorrectly identify a distractor word as a stimulus word seen previously. The authors suggested that if children did not label a picture, it may adversely affect recall, but may not influence recognition.

Jensen, A.R., & Rohwer, W.D., Jr. Syntactical mediation of serial and paired-associate learning as a function of age. Child Development, 1965, 36, 601-608.

Both serial and paired-associate learning was measured for 140 subjects, 20 students each from kindergarten, second, fourth, sixth, eighth, tenth, and twelfth-grades. The subjects at each grade level were matched on IQ and socio-economic status. Half of the students at each grade level learned the pictured pairs under a sentence mediation where the subjects were asked to construct a sentence containing the names of the pictured items; the remaining students were asked to name the paired items. All subjects completed both a paired-associate and a serial task. Each student continued the tasks until he or she had completed one errorless trial for 10 pairs of pictures or until he or she had completed 15 trials. The results were analyzed using the time necessary to reach criterion and the number of trials completed until the criterion was met. The administration of the serial and paired-associate tasks was counterbalanced.

Analysis indicated significant effects due to age, task, and sentence mediation with a significant interaction between age and sentence mediation, between task and sentence mediation, and between age, task and sentence mediation. Sentence mediation was facilitative only for the paired-associate tasks. It was significantly effective at second, fourth, and sixth grades but not at the other grade levels. At about second grade, sentence mediation seemed to eliminate age differences with respect to speed of learning until high school levels where the induced mediation had little effect. The kindergarten children experienced little improvement in the paired-associate tasks with sentence mediation; however, their sentences usually named the paired items with a conjunction without relating the items by an active verb or preposition.

Levie, W.H. Pictorial research: An overview. Viewpoints, 1973, 49, 37-45.

This overview of past research involving pictures in cognitive learning studies briefly summarizes results across studies and presents the author's

concerns about the many variables involved when using pictures as stimuli. The author also reviews reports which indicated young children's potential inability to interpret pictures.

Levin, J.R. What have we learned about maximizing what children learn? (Theoretical Paper No. 49). Madison, Wisconsin: University of Wisconsin, Wisconsin Research and Development Center for Cognitive Learning, July, 1974.

This paper summarizes the current program of research on children's learning at the Wisconsin Research and Development Center with some reference to research performed under other auspices. The main topics include pictures as learning materials, visual imagery as an organizational strategy, and a proposed approach to continued investigation of cognitive development. In particular, Levin reviews research reports on paired-associate learning, recognition and recall, on the influence of individual differences, on the development of imagery strategies (mediation), and on the influence of pictures and imagery strategies on the comprehension of prose.

Levin, J.R. When is a picture worth a thousand words? In Issues in imagery and learning: four papers (Theoretical Paper No. 36). Madison, Wisconsin: University of Wisconsin, Wisconsin Research and Development Center for Cognitive Learning, February, 1972, pp. 1-15.

In this report, Levin summarizes some of his work at the Wisconsin Research and Development Center on the effectiveness of verbal and dynamic imagery strategies and their development with age. His results are presented in conjunction with references to and reviews of related research by other investigators on paired-associate learning and imagery strategies.

Levin, J.R., Davidson, R.E., Wolff, P. and Citron, M. A comparison of induced imagery and sentence strategies in children's paired-associate learning. Journal of Educational Psychology, 1973, 64, 306-309.

Second and fifth graders (128 subjects) were randomly assigned to one of four instructional strategies for 16 pairs; traditional paired-associate directions; induced visual imagery mediation; induced sentence mediation; combined visual imagery and sentence mediation (induced). Half of the subjects in each treatment were asked to name or recall the response item upon presentation of the stimulus; the remaining subjects selected the appropriate response item for each stimulus from a collection of 8 possible responses (recognition).

Analysis indicated a significantly higher performance by the fifth graders. The traditional paired-associate treatment resulted in scores significantly lower than each of the three imagery conditions. No significant difference be-

tween imagery conditions was noted. The recognition response mode produced significantly more correct responses than the recognition mode. The second graders (aged 7 and 8) could employ effectively either the induced visual or sentence imagery.

Lieberman, L.R. & Culpepper, J.T. Words versus objects: comparison of free verbal recall. Psychological Reports, 1965, 17, 983-988.

Two studies were carried out to compare recall of words with recall of objects or pictures. In the first study, 50 college students viewed either a collection of 20 objects or a listing of 20 words naming those objects for 60 seconds. Analysis indicated significantly more items were recalled by students who viewed the collection of objects. In a followup study, 62 college students and 46 high school students viewed either color slides of 24 items or of words naming the items at 2-second intervals. The subjects were then asked to write down a list of the items or words they had seen. Significantly more photographs were recalled than words.

Lynch, S., & Rohwer, W.D., Jr. Grade interaction with words and pictures in a paired-associate task: A proposed explanation. Journal of Experimental Child Psychology, 1972, 13, 413-421.

Noting that the superiority of pictures over words in paired-associate tasks seemed to increase with age, the researchers investigated whether this may be due to a double encoding with both a visual and a verbal label by older subjects. A sample of 108 third graders and 108 sixth graders was selected. Within each grade level, one third of the subjects were selected to view 15 pairs of words. These three groups were also divided in three mediation conditions: no verbalization by the experimenter; experimenter named the pictures or words; or experimenter stated a sentence relating the paired pictures or words. Thus at each grade level there were nine experimental conditions.

Analysis indicated that for the no experimenter verbalization condition, pictures were learned more efficiently and the sixth graders performed better than the third graders. This grade by mode interaction was not present within the experimenter naming or sentence conditions.

McCabe, A.E., Levine, J.R. & Wolff, P. The role of overt activity in children's sentence production. Journal of Experimental Child Psychology, 1974, 17, 107-114.

Forty subjects aged from 4 to 5 years were administered associative learning tasks under one of four conditions. The conditions were: control, subjects were instructed to make a pair of toys play together; sentence, subjects were instructed to make up a story about a pair of toys playing together but the

children did not touch the toys; and combined manipulative sentence, subjects were instructed to make up a story about the toys in the pair playing together and show the story with the toys. The children completed this task with each of 12 pairs of toys. Then each subject was shown the entire collection of response toys and told to choose the toy to go with the stimulus toy, as displayed by the experimenter.

Statistical analysis indicated no significant difference between the sentence and the combined manipulative-sentence treatments. The control group performed at a significantly lower level than each of the other groups. The manipulative group recognized significantly more response toys than either the sentence or combined manipulative-sentence treatments. The children seemed to generate sentence stories without much difficulty.

Mackworth, N.H. & Bruner, J.S. How adults and children search and recognize pictures. Human Development, 1970, 13, 149-177.

The eye fixations of 40 subjects (adults and 6 year olds) were studied as they recognized or inspected a series of displays of varying clarity over 10-second exposure periods. Reliable differences were noted between the children and the adults. For sharp pictures, the children did not adequately cover the display, and they used twice as many small eye movements as did the adults. Unlike the adults, the children were not consistent as to the areas they usually selected when viewing blurred displays.

Mandler, J.M. & Stein, N.L. Recall and recognition of pictures by children as a function of organization and distractor similarity. Journal of Experimental Psychology, 1974, 102, 657-669.

This study investigated children's ability to describe a complex picture, to recall complex pictures, to recognize whether pictures were the same or different from stimuli no longer present, and to choose which of two pictures was most like the original stimuli. Half of the pictures depicted items randomly spaced; the remaining pictures depicted a meaningful relationship between the same items. Subjects were 168 first and second graders aged 6 to 8 years.

No effect due to grade level was noted on either the description or recall tasks. Those pictures depicting related items were recalled significantly more than pictures depicting unrelated items, but no difference between descriptions of the pictures was revealed. There was a high correlation between recall and description.

Second graders correctly identified significantly more pictures as same or different from the stimuli than did first graders. Recall and description were poor predictors of accuracy of recognition. Pictures with related items were correctly identified more than pictures with unrelated items.

Left-right reversals were usually identified by 7 and 8 year olds with an overall accuracy of 91%. Also pictures which deleted some items from the original stimuli were detected by the children.

Milgram, N.A. Verbal context versus visual compound in paired-associate learning by children. Journal of Experimental Child Psychology, 1967, 5, 597-603.

Ninety children, aged 4, 7 and 9 years, were administered paired-associate tasks with imposed pictorial elaboration, imposed verbal elaboration, or no elaboration. Analysis indicated that for the 7 and 9 year olds, either verbal or pictorial elaboration resulted in significantly better scores than no elaboration. For the 4 year olds, the verbal elaboration condition yielded significantly higher scores than no elaboration, but no significant difference was noted between the pictorial elaboration and no elaboration treatments.

Montague, R.B. The effect of mediational instructions on associative skills of first grade innercity children. Paper presented at the annual meeting of the American Educational Research Association, Minneapolis, Minnesota, March, 1970. (ERIC Document Reproduction Service No. ED 038 177).

In this investigation, 84 first graders from the innercity of Chicago completed 12 paired-associate trials with black and white line drawings. Half of the subjects had one of three mediation conditions; visual imagery, and sentence elaboration, or naming the items. Results indicated that the visual imagery and sentence elaboration treatments yielded significantly higher scores than that obtained from the labeling condition. No significant difference was noted between the induced sentence treatment and the imposed sentence or visual imagery conditions.

Odom, P.B. & Nesbitt, N.H. Some processes in children's comprehension of linguistically and visually depicted relationships. Journal of Experimental Child Psychology, 1974, 17, 399-408.

Paired-associate learning of 64 fifth graders and 64 kindergarten children was examined under one of four conditions: imposed pictorial elaboration; imposed verbal elaboration; imposed verbal and pictorial elaboration; no elaboration. Twenty-four pairs of line drawings were used.

Statistical analysis indicated that the combined verbal and pictorial elaboration resulted in significantly higher scores than each of the other conditions; the no elaboration treatment yielded significantly lower scores than each of the other conditions. A significant age and IQ effect was noted, but the age effect was distributed over all conditions. No evidence of a develop-

mental trend from imposed verbal to imposed pictorial elaboration was indicated as there was not a significant interaction between age and the pictorial or verbal elaborations.

Paivio, A. & Csapo, K. Concrete image and verbal memory codes. Journal of Experimental Psychology, 1969, 80, 279-285.

Ninety-six college students completed either immediate memory or verbal free recall tasks using either abstract words, concrete words, or easily labeled pictures as stimulus items. Presentation rate was either fast (.0625 second) or slow (.1875 second). A significant effect due to rate of presentation, type of task, and type of stimuli was noted with a significant interaction between type of task and stimuli. In free recall, pictures were recalled most frequently, whereas in the immediate memory task, they were remembered the least.

In a similar study, 192 college students viewed the same kinds of stimuli for serial learning as for recognition tasks. A significant interaction was noted as pictures produced the lowest level of serial learning but were recognized most frequently. Serial learning was affected by the rate of presentation. At the slower rate of presentation, pictures were recognized significantly more than abstract words.

Paivio, A. & Yarmey, A.D. Pictures versus words as stimuli and responses in paired-associate learning. Psychonomic Science, 1966, 5, 235-236.

Eighty-four college students completed paired-associate tasks with the picture-picture, picture-word, word-picture and word-word stimulus-response conditions. Results revealed that paired-associate learning was highest with pictorial stimuli and word responses.

Reese, H.W. Imagery and contextual meaning. Psychological Bulletin, 1970, 73, 404-414.

In paired-associate tasks, pictorial imagery is less effective than sentence elaboration for young children, but, for older children, this distinction is not present. Six explanations are considered: (a) images may facilitate performance only if described verbally; (b) verbal information may be recalled more readily than visual information; (c) visual mediators may not be generated; (d) although visual and verbal mediators are generated, only verbal mediation is effective; (e) visual interaction may not be recalled, rather only the individual items involved may be retained; (f) the visual interaction may not be "read" or observed. Reese offers evidence to support the last interpretation.

Rohwer, W.D., Jr. Constraint, syntax and meaning in paired-associate learning. Journal of Verbal Learning and Verbal Behavior, 1966, 5, 541-547.

Two hundred twenty-four sixth graders were divided into 14 groups of varying verbal training prior to completing paired-associate tasks with noun pairs. The groups varied with respect to the meaningfulness of the verbal phrases they were taught to form in order to relate the paired items, to the grammatical structure of the phrases (conjunction, preposition, or active verb), and to the syntactic structure (accepted form or nonsense, scrambled form). Analysis of the results indicated subjects who formed meaningful phrases within the accepted forms of English grammar learned significantly faster than subjects who had no verbal pretraining. Subjects who were taught to form nonsense phrases did not perform as well as those forming acceptable phrases, pointing out the need for both semantic and syntactic structure in order to facilitate learning. Within the semantic constraints, subjects who formed phrases relating the paired items by an active verb achieved the highest level of learning, followed by students forming prepositional phrases, and lastly by subjects using only conjunctions to relate the paired items.

Rohwer, W.D., Jr. Images and pictures in children's learning: Research results and educational implications. Psychological Bulletin, 1970, 73, 393-403.

This paper reviews a number of studies concerned with the role of imagery in children's learning. In particular, investigations concerning the characteristics of the paired items in associative learning (concrete or abstract words, pictures), the type of elaboration or mediation involved within the paired items, and the kinds of elaboration or mediation instructions supplied or suggested by the experimenter. Evidence is presented to indicate that younger children are more facilitated in associative learning by verbal elaboration than by pictorial modes and that this may be a developmental trend. Educational implications are presented.

Rohwer, W.D., Jr. & Levin, J.R. Action, meaning and stimulus selection in paired-associate learning. Journal of Verbal Learning and Verbal Behavior, 1968, 7, 137-141.

Fifth graders (112) were presented 12 pairs of words. The control group saw only a written paired listing of the words. The experimental group saw written 3-word sentences where the word pairs were connected by a verb. The meaningfulness of the sentences, the stimulus forms (verb or noun), and the verb form in the sentence (active or still) were varied. Analysis indicated no significant difference due to verb form within the sentences. The meaningful sentence treatments produced significantly more learning than either the meaningless sentence treatments or the control conditions. Verbs were inferior stimuli to nouns.

Shepard, R.N. Recognition memory for words, sentences, and pictures. Journal of Verbal Learning and Verbal Behavior, 1967, 6, 156-163.

This article is a report on three studies concerning adult recognition of words, sentences, and pictures. In the first study, 17 college students were shown 540 nouns and adjectives; half of these words are used frequently in conversation while the remaining words are rarely used in conversation. The subjects were then given 600 word cards each containing two words and were asked to identify which words were seen previously and which words had not been identified in the original listing. Analysis indicated that the rare words were recognized with 92.5% accuracy and the common words with 84.4% accuracy. The overall median was 90% correct with a mean correct identification of 88.4%

In the second study, 17 college-age students were given 612 sentences. Then they were presented with 68 sentence pairs and asked to identify those sentences they had initially seen. Mean correct recognition was 89% with a median of 88%.

Technical and clerical employees (34) were the subjects of the third study. These adults viewed 612 color pictures initially. Then the subjects were asked to identify the stimulus pictures from 68 picture pairs. Sixteen of these subjects were again administered the recognition test after a 2 hour, 3 day, 1 week, or 4 month delay. On the immediate recognition test, the mean correct identification was 96% with a 98.5% median. The mean and median identification levels respectively after 2 hours were 99.7% and 100%, after 3 days 92% and 93%, after 7 days 87% and 92%, and after 4 months 57.7% and 57%.

Stein, N.L. & Mandler, J.M. Children's recognition of reversals of geometric figures. Child Development, 1974, 45, 604-615.

A report on three studies involving the recognition of reversals of geometric figures by 4 through 7 year olds is presented in this paper. In the first study, subjects aged 5 to 7 1/2 viewed the stimulus picture depicting three different geometric figures. Each child was asked to describe the picture while viewing it; then the picture was removed. At that time, the subject was shown nine transformed pictures, involving orientation and/or location changes, and was asked to tell if each of these pictures was the same or different from the stimulus. The overall recognition rate was 85%, ranging from 66% correct on transformed picture showing rotation of only one of the geometric figures to 100% recognition of the picture depicting a left-right reversal with a location change. If the transformed picture depicted both a location and an orientation change, the subjects were less apt to verbalize the orientation change; if the only change was orientation, the children had no difficulty mentioning the change.

In a followup study, 30 children (aged 5-7 1/2) viewed stimulus cards and immediately after describing each stimulus they classified three transformation cards as the same or different from the stimulus. The target cards depicted single or paired geometric figures; the transformed cards depicted simi-

lar figures with 90 degree rotation or left-right reversals. Again recognition was from 80% to 100% except for recognition of left-right reversal of a diagonal bar which was at chance level.

A similar study involving 24 children aged 4 to 6 years required the subjects to choose the stimulus item from a collection showing the figure in varying rotations or orientations. The 5 and 6 year olds performed significantly higher than the 4 year olds with a 87%-100% accuracy.

Stein, N.L. & Mandler, J.M. Development of detection and recognition of orientation of geometric and real figures. Child Development, 1975, 46, 379-388.

Seventy-seven children from kindergarten and second grade viewed target cards depicting either three geometric figures of drawings of three common items (candy cane, bow, turtle). A recognition test was administered one week later followed by a matching-to-sample task and then another recognition test. No significant difference due to picture form (real or geometric) was noted. On the initial recognition test, the older children performed significantly higher than the kindergarten children, but no difference with respect to grade level was noted on the second recognition test. Scores on the matching-to-sample task averaged 92.9% to 100% correct. The kindergarten children were less likely to verbalize an orientation change if a location change was also present.

Varley, W.H., Levine, J.R., Severson, R.A., & Wolff, P. Training imagery production in young children through motor involvement. Journal of Educational Psychology, 1974, 66, 262-266.

Using toys as stimulus and response items, 80 kindergarten and first grade children were given 15 paired-associate tasks to complete. The paired toys were selected so that a plausible interaction was possible. The five training conditions were: (a) control, where the experimenter demonstrated toy interaction for 4 of the pairs and the subjects were told to imagine interactions for the remaining 4 pairs; (b) subjects generated their own imagery by playing with 8 pairs of toys; (c) subjects were told to draw pictures to show interaction of the 8 paired toys; (d) children were given training on drawing interaction for 4 pairs, then told to draw an imagined interaction for the remaining 4 pairs of toys; (e) subjects were given practice play sessions to show interaction within 4 pairs and then told to imagine interaction before showing it for the remaining 4 pairs. During the testing situation, the subjects were presented with 15 paired toys. Then the experimenter picked a stimulus toy and the subject chose the paired response toy.

Statistical analysis indicated that each of the drawing or play training conditions yielded a significantly higher number of correct resonses than the control condition for the kindergarten children; no significant difference was

noted for the first graders. There was no significant difference in accuracy between the four drawing and play experimental groups at either grade level.

Wohlwill, J.F. and Weiner, M. Discrimination of form orientation in young children. Child Development, 1964, 35, 1113-11127.

Twenty-four children aged 4 to 4 1/2 were given matching-to-sample tasks that required them to distinguish a target figure from its "up-down" or left-right reversal. The stimuli were meaningless, abstract geometric forms. The mean number of errors per child for the 32 test trials was 5.4. A significant difference was noted within the reversals as more up-down reversals were recognized than left-right reversals.

Wolff, R. & Levine, J.R. The role of overt activity in children's imagery production. Child Development, 1972, 43, 537-547.

In order to determine the age range during which a child's ability to generate images develops rapidly, these investigators presented 80 kindergarten and third grade children with 16 paired toys within one of four conditions. In the control condition, the paired toys were presented, and the subjects were instructed to remember "which toys go together." In the imagery condition, the subjects were told to imagine the paired toys "playing together." In the experimenter-manipulative condition, the subjects watched the experimenter make the paired toys interact. In the subject-manipulative condition, the subjects were instructed to make the paired toys interact. Each pair was present for about 7 seconds. Then the 16 response toys were displayed and, upon presentation of a stimulus toy by the experimenter, the subject chose the response toy.

Analysis revealed that the third graders identified significantly more correct responses than the kindergarten children. At the kindergarten level the two manipulative conditions produced significantly more correct responses than either the control or imagery conditions. The third graders, within each of the experimental conditions (including imagery), recognized significantly more response items than did the third graders in the control condition.

In a second study, 40 kindergarten and first grade children were presented 12 pairs of toys. The children saw each pair which was then placed in a container by the child. The toys were then no longer visible, but the children were touching the toys. Half of the subjects were told to imagine the toys playing together, but they could not move their hands to manipulate the toys within the container. Analysis indicated that the first graders had significantly more correct responses in the subsequent testing situation than did the kindergarten children. Also children within the overt, but invisible, activity condition identified significantly more response toys than the children in the imagery condition who merely held the toys outside of their vision.

II. Children's Interpretations of Progressively Changing Pictures

Before a child can characterize a dynamic picture or sequence of pictures depicting a mathematical event by means of a number sentence, it is necessary that the child recognize motion between the depicted sets. It is also necessary that the pictures within a sequence be interpreted as representational of the gradual change which makes up the total event depicted by the sequence.

In 1967, Schnall began a series of studies investigating children's interpretations of progressively changing pictures; in particular, the research probed for developmental differences in the verbal description of changes of an object depicted in different states. Subjects ranging from first graders to college students viewed sequences of pictures depicting a figure or figures being displaced along a line in succession of discrete steps. The figures involved were either geometric forms (circle, triangle, oval) or concrete forms (stick-figures). Other variables included color, number of pictures in a sequence, presence or absence of anchoring features, and the number of figures in any given picture.

The verbal description of the subjects was classified as either subordinate or discrete. Subordinate descriptions were characterized by the use of active verbs to describe the progressive change of the figures (e.g., to roll, to move, to grow). In these descriptions, each figure within the picture was viewed as a single entity undergoing a change and the series of pictures served to display the figure's position over time. Discrete descriptions, characterized by forms of the verb "to be," did not attribute any change or movement to the figures but rather described the physical mode of each picture (e.g., "There was a stick-figure here, a stick-figure here, and another one over here."). Schnall maintained that these two types of descriptions reflected a different perception of the sequence. This supposition was supported by the observation that subjects' drawings of the sequence differed systematically as a function of of the type of description provided by the subject (Schnall & Kemper, 1968).

This series of studies revealed that spontaneous subordinate descriptions were more frequently offered by older subjects (11 year olds or college students) than by younger children (6 or 7 year olds) when the figure depicted in the sequence was a geometric form, but that this age difference tended to disappear when the same figure displacements were portrayed by stick-figures. Schnall suggested that this may mean that the concept of motion or change in the young child is dependent on his own experience of change or motion by familiar objects (Kasdorff & Schnall, 1970; Schnall, 1968; Schweitzer & Schnall, 1970).

Kasdorff, C.A. III & Schnall, M. Developmental differences in the integration of picture series: Effects of variations in object-attribute relationships. Human Development, 1970, 13, 188-200.

This study investigated whether the hypothesized development of integration within pictured sequences was due to younger children's inability to la-

bel abstract figures or due to a relationship between the figure and the concept of change. If a relationship between the depicted figure and change was necessary, then subjects should be more likely to note progressive motion for familiar figures undergoing appropriate changes than for familiar figures undergoing inappropriate changes or for abstract, geometric figures undergoing inappropriate changes. First, sixth and thirteenth graders (176 subjects) viewed three series characterizing one of the conditions above. The changes were in color, shape or position. The subjects were asked to describe what they had seen.

Analysis indicated no significant difference in the descriptions offered by the sixth graders and the college students. The first graders' descriptions had significantly fewer integrated subordinate descriptions. The level of integration decreased significantly from familiar figures with appropriate changes to familiar figures with inappropriate changes to geometric figures. Within the color change sequences, familiar figures were integrated significantly more than the abstract figures. Within the sequence depicting a change in shape, familiar figures with appropriate changes were integrated significantly more than the other two conditions. No significant difference between the conditions was noted within the sequences depicting changes in position.

Schnall, M. Age differences in the integration of progressively changing visual patterns. Human Development, 1968, 11, 287-295.

Eighty subjects within four age groups (mean age 7.1; 9.2, 11.2 and 18.8 years) viewed two sequences of pictures depicting progressive changes of position and size of two figures of differing colors. After viewing, the subjects orally described what they had seen. Older subjects have significantly more subordinate descriptions than younger children. Across age groups, significantly more subordinate descriptions were offered for the concrete sequence (stick-figures) than for the geometric sequence. This difference decreased with an increase in age. Although the descriptions of the older subjects differed significantly from those of the younger subjects on the geometric sequence, this difference was not apparent on the concrete sequence.

Schnall, M. Global errors in children's reproductions of progressively changing pictures. The American Journal of Psychology, 1967, 80, 213-220.

The design of this study allowed investigation of children's interpretation of progressively changing pictures involving two objects, which were either the same or differing, with or without a stable background feature. The sequences were composed of five pictures depicting two objects undergoing a gradual change and then one of the objects remained stationary while the other object returned to its original state. Thirty-two subjects from each of four grade levels (second, third, fifth, and sixth grades) viewed a sequence and then drew pictures to show what they had seen. The subjects were also

asked to orally describe the sequence.

Analysis revealed that common errors involved a complete or partial return of both objects to the original state or depicting one object in the "changed state" in all drawings. These errors were significantly correlated with verbal descriptions involving active verbs and with sequences involving objects of differing colors. The presence of an anchoring background for the stationary object did not correlate significantly with any type of error. No significant difference between age groups was noted.

Schnall, M. & Kemper, T. Modes of organizing progressively changing stimulation: A developmental study. The American Journal of Psychology, 1968, 81, 375-383.

This study investigated the effect of a three-picture or a five-picture series (depicting displacement of a figure along a line of constant length) on children's verbal description and drawings of the series after its removal. Subjects were 144 first, third, and fifth graders. Half of the children viewed a three-picture series while the remaining subjects viewed a five-picture series. The design allowed for investigation of the effect of figure type (circle or stick-figure) and direction of the displacement (up or down).

No significant difference in descriptions was noted due to the direction of the displacement. Significantly more subordinate descriptions were offered within the three-picture series for stick-figures than for the circle; no significant difference was noted between the descriptions for the first five-picture series. Subordinate descriptions were significantly correlated to the five-picture series across all grade levels. Redundant drawings (producing six or more drawings to depict the change) significantly decreased with age, but significantly more redundant drawings were produced by subjects who had seen the five-picture series than by subjects who had seen the three-picture series. A correlation between the number of drawings offered and the verbal descriptions was noted.

Schweitzer, T.M. & Schnall, M. Sequence effects in the abstraction of the concept of progressive change. Human Development, 1970, 13, 201-212.

Four sequences, each consisting of nine pictures, were developed. One sequence depicted a stick-figure undergoing a location change from left to right toward a stationary object. The fourth sequence depicted a geometric shape changing in both form and location. Subjects were 125 children from 6 to 9 years of age.

Analysis of the descriptions revealed that significantly more subordinate descriptions were given by subjects who viewed the stick-figure sequence during one of the three presentations. This concrete sequence seemed to serve as a transitional step to the geometric sequences, particularly for the younger subjects.

III. Characteristics of Pictures

Before a child can attach a mathematical interpretation to a picture or sequence, it is necessary that the child be able to recognize what actions are occurring in the scene which is being presented by the picture(s). This means that the child must be able to recognize and interpret artistic cues within the picture.

Gibson's theory of pictorial perception (1971) defines a picture as "a display of optical information" (p. 83) and classifies it as a surrogate, since it is produced by one person in order to relate an object, place, or event not present to another individual whose perceptions are, in turn, aroused by the picture. As surrogates produced by people, pictures involve a distortion of the objects or events they represent since they portray the artist's conception or perception. This distortion may be intensified if the viewer is not able to perceive the picture as intended by the artist. In a recent survey of pictorial research, Hanes (1975) stated that perception may be affected "not only by the variables inherent in the stimulus array, but also by those attributes of the learner involved in the perceptual process" (p. 12).

Pictorial materials may vary along many dimensions. Fidelity is the degree to which a picture provides a viewer with "sensory input" similar to that which he would have if he were viewing the scene represented by the picture (Travers & Alvarado, 1970). Fidelity is one dimension by which pictures may vary. Another dimension is the presence or absence of settings in which the central objects are presented. The amount of detail (color, line drawing, shading, photographs, etc.) and the influence of three-dimensional cues are other dimensions. The extent to which a picture is stylized or realistic is yet another dimension. Stylized representations are characterized by use of adopted convention codes to portray features which, as judged by the code, represent the real world even though they deviate from the real optical code. Cartoons are stylized pictures, as are many illustrations in elementary school textbooks (Travers, 1969).

While cartoons typically rely on a stylistic representation of the fact, textbook illustrations commonly use stylized conventions to suggest movement. In order to derive the information intended by the illustrator, a student must convert the still picture in a textbook into a dynamic scene. The static picture must be viewed as an instance that has emerged from previous events and as an instance which is leading up to and causing new events. Three conventions typically employed to imply motion in static pictures are to depict a moving object as blurred, to represent the moving object in a state of non-equilibrium, or to draw vibration or wake lines behind the moving object (Travers, 1969; Travers & Alvarado, 1970).

Friedman and Stevenson (1975) investigated developmental changes in the understanding of implied motion. Each of their subjects viewed 45 line drawings of stick-figures and classified them as "still" or "moving." The line drawings depicted moving figures by the blurring or vibration convention (cartoon cues), by showing parts of the body (usually the limbs) in varying positions (postural cues), or by showing parts of the body in multiple positions.

Some of the figures which depicted a position other than that defined as still were in the state of equilibrium. This may have been a confounding factor within the study. Analysis indicated that reliance on cartoon cues increased with age while reliance on postural cues decreased with age.

Friedman, S.L. & Stevenson, M.B. Developmental changes in the understanding of implied motion in two-dimensional pictures. Child Development, 1975, 46, 773-778.

A human figure test presenting 45 stick-figures was administered to each of 102 subjects (preschoolers, first graders, sixth graders, and college students). The test presented 13 still figures, 9 figures utilizing cartoon cues, 20 figures utilizing postural cues, and 3 figures utilizing multiple cues.

Analysis of variance indicated a significant effect due to type of picture with significant interactions of age and picture type as well as age and sex. Regression analysis indicated that, as age increased, the percentage of pictures involving cartoon and multiple cues which were interpreted as moving increased while the percentage of postural pictures interpreted as as moving decrease. Preschool and first grade children saw significantly more postural pictures as moving, but interpreted no more movement in pictures utilizing cartoon cues than within the still pictures.

Gibson, J.J. The information available in pictures. Viewpoints, 1971, 47, 73-95.

In this article Gibson presents his theoretic definition of a picture as it applies to paintings or photographs (a point-to-point correspondence of brightness or color), but indicated that the definition does not apply to either line drawings or caricatures. He states that a picture is neither the source of differing light rays nor a layout of artistic symbols but rather "a display of optical information" (p. 83). He also reviews the picture-perception theories of Kepes and Goodman. Gibson suggests that current evidence indicates that children do not notice the "aspects of an object or the perspective of the environment" rather they notice the "set of invariant distinctive features of objects and the rigid layout of environmental surfaces" (p. 86).

Hanes, M.L. The research on how children learn from pictures. Viewpoints, 1973, 49, 11-20.

In this review of research on learning from pictures, Hanes notes the diversity within psychological studies involving perceptual learning and the small number of studies investigating children's learning form pictures within an educational setting. He notes that both applied and theoretical researchers are aware of the "active role of the perceiver" (p. 12) in perception and states

that the attributes of pictorial stimuli are influential on learning within each developmental stage.

Travers, R.M.W. A study of the advantages and disadvantages of using simplified visual presentations in instructional materials. Final Report. USOE Grant No. OEG-1-7-070144-5235, June, 1969. (ERIC Document Reproduction Service No. ED 031 951)

Travers reports on three studies he conducted concerning the effect of detail on the recognition of pictured items, the use of realistic or abstract illustrations to teach the concept of "half," and age differences in picture perception. His review of previous research summarized Gibson's theory of picture perception, as well as discussed the artistic dimensions by which pictures may vary.

Travers, R.M.W., & Alvarado, V. The design of pictures for teaching children in elementary school. AV Communication Review, 1970, 18, 47-64.

Noting that children perceive pictures differently from adults and typically obtain less information from pictures than adults, the authors review research studies concerning children's gradual ability to handle complex stimuli within a picture, interpreting the picture as a whole. Studies investigating children's ability to perceive motion and the influence of detail are also reviewed.

IV. Children's Perceptions of Pictures

When confronted by a picture, what does a child notice? Which features are singled out as figures and which features are absorbed by the background field? Interpreting data collected by Ames and her associates (1953) as to how 50 children from ages 2 through 10 responded to the Rorschach test, Travers (1969) noted that the first "genuine percepts" based on the blot involved details and, as the children grew older, they began to correctly perceive the blot as a whole. This interpretation of Ames' study by Travers is consistent with the findings of the many studies of figurative perception conducted by Elkind (1969). As summarized by Elkind:

> With increasing age, the child is better able to reverse figure and ground, to integrate parts and whole, and to scan configurations in more systematic, complex and novel ways. In short, our data suggest that the course of perceptual growth is marked by an increased tendency to act upon any given configuration so as to perceive all of its many and varied facets (p. 24).

Although the studies by Elkind and Ames indicate that children are able to perceive wholes by the mid-elementary grades, there is a danger in generali-

zing their results from artificial experimental materials to visual stimuli used in the classroom. Observational studies using typical illustrations suitable for children have noted three levels of sequential growth in children's ability to interpret pictures--namely, enumeration, description, and interpretation. The level of interpretation is dependent upon the ability, experience and maturity of the child, as well as his age (Amen, 1941; Carpenter, 1964; Gray & Klaus, 1965).

Miller (1938b) conducted an investigation to determine what third grade children spontaneously saw in pictures. One-hundred children were individually shown six textbook pictures suitable for their grade level and asked to identify items as well as the relationships or theme depicted by each picture. Based on the low level of identification and interpretation revealed in this study, Miller suggested that if pictures were to be of value in a learning experience, teachers would have to direct their students' attention to the important items in the picture and to develop the interpretation of these items.

Using unambiguous representation of real situations, Travers (1969) also investigated the development of children's pictorial perception. Sixty subjects ranging from nursery school children through sixth graders, viewed six photographs through a tachistoscope. Each photograph was exposed ten times, each time for a quarter of a second, and after each presentation, the subject was asked to tell what he had seen. Travers assumed that this technique of momentarily exposing the entire picture over a period of time would provide an indication of how the child assimilated the information within the picture. The results indicated a significant increase in the number of identifications as age increased. To some extent, the presence of color influenced the number of correct recognitions of motion and theme. More striking was the fact that the younger children (N-K) tended to become preoccupied with a specific detail and repeat that identification over and over, ignoring the remaining aspects of the picture. Motion was rarely perceived by the younger children in comparison to their object identifications; however, their limited perception of the entire picture would lower the probability of their noting dynamic relationships within the photograph.

In a follow-up study, Vallan (1972) investigated whether the indicated superiority of color pictures over black and white pictures for communicating themes and motion was due to the simple presence of color or to the increased realism which natural color pictures convey. He presented sixth graders with 24 slides, half of the slides pictured static events while the remaining slides depicted dynamic events involving motion. The slides were in either realistic color, contrived color, or black and white. Analysis indicated that not only color, but also the degree to which the color represented reality led to an increased perception of motion.

These studies suggest that primary and preschool children have difficulty relating the characteristics of pictures in terms of theme and motion, thus limiting their ability to perceive the dynamic nature of pictures.

Amen, E.W. Individual differences in apperceptive reaction: A study of the response of preschool children to pictures. Genetic Psychology Monographs, 1941, 23, 319-385.

This article is a report of a study which analyzed the responses of 77 preschool children (2-, 3-, and 4-year olds) to a series of 15 pictures presented during two viewing sessions. The pictures presented a minimum of detail, but depicted characters and scenes which the subjects could identify with themselves (e.g., a birthday party, two children with a dog). Five of the 15 pictures had movable parts and the children were asked to identify the theme of the picture or the movable characters which could go with the theme of the picture and to then make a new picture by moving the characters or items. For each of the ten static pictures, the children were asked to tell a story about the picture.

Analysis of responses revealed three levels: naming or identification of object (enumeration); description in terms of overt activity (description); and, inference of emotional status (interpretation). As age increased, so did the tendency to note activity and to interpret the events depicted. Also responses indicated a developmental trend in part-whole perception from emphasis upon details or parts of the picture (frequently insignificant) to recognition of the whole event depicted in the picture, rich in details. Children of all age groups were susceptible to misinterpretation of a picture due to emphasis or interest upon a detail "which has not been accurately related to a whole of which it is a part" (p. 348).

Ames, L.B., Learned, J., Metraux, T., and Wheeler, R. Development of perception in the young child as observed in responses to Rorshach test blots. Journal of Genetic Psychology, 1953, 82, 183-204.

This study traced the development of perception in 50 upper middle class children in response to Rorschach test blots. The children were observed at six-month intervals from age 2 through 6, and then yearly through age 10. Younger children (aged 2-3 years) tended to respond in single-word answers conveying the general idea which the blot suggested to them rather than describing or identifiying with reference to details within the blot. At about 4 years of age, the responses indicated perception based upon the details within the blot. Responses at this age included naming of individual parts of the blot which may or may not be ever related as a whole by the subject to describe the entire blot. By age 6, the children were beginning to describe wholes based upon a combination of details perceived in the blot and, for the first time, were noting movement in their interpretations. By age 9, the children's repsonses began to indicate a shift toward adult perception noting movement, color and shading as well as form.

Carpenter, H.M. Study skills: Developing picture-reading skills. The Instructor, 1964, 74, 37-38; 130.

The ability to scan pictures is not equivalent to the ability to read pictures and children must be taught to derive meaning from pictures. Based upon this premise, the author outlines the levels of picture interpretation development and suggests procedures which an elementary school teacher may use to assist students in picture reading.

The three developmental levels are: enumeration (merely listing the objects in a picture), description (describing the quality or action depicted in a picture) and, interpretation (perceiving relationships and making inferences). However, the author cautions teachers that development through these levels is determined not only by age, but also by ability, experience and maturation.

Elkind, D. Developmental studies of figurative perception. In L.P. Lipsitt and H.W. Reese (Eds.) Advances in Child Development and Behavior. New York: Academic Press, 1969, pp. 1-28.

In this paper, Elkind considers the meaning of figurative perception, summarizes a theoretical basis for research into figurative perception as offered by Piaget, and reviews some of the research studies conducted by he and his colleagues on the development of figurative perception.

Gray, S.W., and Klaus, R.A. An experimental preschool program for culturally deprived children. Child Development, 1965, 36, 887-898.

This article is an interim report of a four-year intervention project for culturally deprived children which attempted to provide an environment of potential learning experiences for 44 experimental subjects through three 10-week summer sessions and weekly home visits throughout the year. The project focused on developing attitudes conducive to later school achievement as well as stimulating language development, encouraging ordering and classification of objects, and aiding in the development and understanding of the meaning of symbols as well as the discrimination of forms and colors. Picture books were a major stimulus as the children were read to, encouraged to look at the pictures during the reading session, and later asked to discuss the story. During the first year's summer session, the children were not able to assess the meaning of a picture as adequately as middle-class children of the same age. However, tests of intelligence and language prior to school entrance (third year of the program) indicated significant gains within the experimental group and a reading readiness level comparable to that of typical entering first graders.

Hagen, M. Picture perception: Toward a theoretical model. Psychological Bulletin, 1974, 81, 471-497.

Hagen describes J.J. Gibson's theory of picture perception and outlines the need for further research to systematically investigate, within Gibson's model, the structural makeup of pictures and their effect on perception. The basic elements of pictures are described and studies concerning pictured item recognition or identification and pictorial depth perception (particularly the use of Hudson's pictorial depth perception test) are reviewed. Hagen lists five tasks or skills necessary for successful perception of pictures.

Miller, W.A. What children see in pictures. Elementary School Journal, 1938b, 39, 280-288.

One hundred third grade children viewed six pictures chosed from books suitable for third grade use. The children were asked to tell the experimenter "all the things you see in it (the picture), what you think when you are looking at it, and what you think is happening in the picture" (p. 282). No time limit was imposed. The mean identification level per child was one-third of the potential numbers of items within each picture; however, only 19.5% of the potential identifications, including relationships between the characters in the picture, were noted by the children. Only in one picture did more than half of the subjects correctly identify the theme of the illustration. The children tended to view the items within the picture in isolation, rather than as parts of a unified whole. Age and sex were not factors. Children of above-average intelligence identified more items than children of below-average intelligence.

Travers, R.W. A study of the advantages and disadvantages of using simplified visual presentations in instructional materials, Final Report. USOE Grant No. OEG-1-7070144-5235, 1969. (ERIC Document Reproduction Service No. ED 031 951)

Travers reports on three studies he conducted--namely, the effect of detail on the recognition of pictured items; the use of realistic or abstract illustrations to teach the concept of "half"; and age differences in picture perception.

In the first study, 49 subjects (elementary school and college students) viewed 12 pictures of common objects (e.g., bed, airplane, shoe) at three different levels of detail through a tachistoscope for 6-second intervals. The subjects were asked to identify the pictured item after each presentation. Results indicated that increasing detail led to a significantly higher recognition level. Increasing detail within the outline seemed to assist recognition at the same level as shading (depth cues). No evidence was found to suggest that young children were more dependent on outline cues than were adults.

In the second study, 100 nursery school children were taught the meaning of "half" using either pictures of fruit or baked goods (realistic) or pictures of geometric shapes (abstract). The criterion test required the students to identify which of 20 pictures (10 abstract, 10 realistic) depicted one-half. All of the subjects performed better on the test items featuring realistic pictures. Travers hypothesized that the realistic training materials developed skills which were not easily transfered to abstract materials, whereas the abstract materials provided skills which were transferred to the realistic materials.

In the third study, 60 subjects (nursery school children, kindergarteners, first, third and sixth graders) viewed six photographs of common, but fairly complex scenes. Each photograph was exposed through a tachistoscope for a quarter of a second, and then the subject was asked to tell what he had seen. This procedure was repeated ten times for each photograph. The proportion of errors tended to be larger for black and white pictures than for colored pictures, particularly in identification of themes or motion. Younger children tended to repeat the same response over and over while older children expanded their perception with each presentation of the photograph. Motion was rarely perceived by the younger children in comparison to their object identifications.

Vollan, C.J. Effects of black and white, authentic and contrived color on children's perceptions of dynamic picture content. Paper presented at the annual meeting of the Association for Educational Communication and Technology, Minneapolis, Minnesota, April 16-22, 1972. (ERIC Document Reproduction Service No. ED 062 822)

This study investigated whether the suspected superiority of color pictures over black and white pictures for communicating dynamic picture content was due to the realism of authentic color or simply to the presence of color. Ninety sixth graders viewed 24 slides depicting 12 static and 12 dynamic events. Eight of the slides were in black and white, eight were developed using an authentic color process, and eight of the slides depicted contrived colors. The pictures were balanced with respect to the development process. The subjects viewed each slide five seconds and then, during a 90 second interval, wrote down what they had seen before viewing the next slide.

Analysis of variance indicated that the dynamic nature of the pictures were noted within authentic color slides significantly more often than within black and white slides which, in turn, yielded significantly more dynamic descriptions than the contrived color slides. The authors cautioned readers not to generalize their results to printed pictures.

V. Children's Picture Preferences

The typical procedure for investigating children's picture preferences varies from displaying a series of illustrations and asking the children to rank or rate the pictures to a comparison by pairs technique, whereby the child-

ren choose the preferred picture form pairs of pictures eventually forming a ranking of all available pictures. Studies on children's picture perference have noted that the children prefer pictures depicting action (Hildreth, 1936; Whipple, 1953) and involving people, places, or incidents with which they are familiar (Waymack & Hendrickson, 1932; Williams, 1924).

Other picture preference studies indicated that children prefer color over black and white pictures (Bamberger, 1922; Bloomer, 1970; Freeman & Freeman, 1933; Hildreth, 1936; Mellinger, 1932; Rudisill, 1952) and saturated color over light tints (Bamberger, 1922; Clegg, 1968; Freeman & Freeman, 1933). Pictures using many colors are preferred over pictures with fewer colors (Amsdens, 1960). However, color is more appealing if it is realistic (Rudisill, 1952; Stwig, 1974; Whipple, 1953), even to the extent that children preferred uncolored realistic illustrations over unrealistic colored illustrations (Rudisill, 1952). This preference for realistic over stylistic or impressionistic pictures has also been noted by other researchers (Clegg, 1968; Hildreth, 1936; Mellinger, 1932).

French (1952) noted that 6 and 7 year old children typically drew pictures which were classified by even, unaccented, unbroken outlines with localized color without variations in shading, within the outlines of flat, two-dimensional, familiar objects. The complexity of children's drawings generally increased with age until, at about 11 years of age, children drew pictures with sketchy, irregular outlines of varied emphasis with shaded color, utilizing conventions of size and overlaps with attempts at linear perspective to portray three dimensions. Classifying these types of drawings as simple or complex, French composed 13 pairs of illustrations, with each pair portraying the same scene in a simple and in a complex manner. When asked to choose the preferred picture from each pair, younger school children preferred the simpler pictures while older children preferred the complex pictures. A reversal in preference from simple to complex illustrations occurred in the fourth grade. Stewig (1974) also found that young children preferred pictures with fewer details.

The preference for complexity in older children may be related to their increased capacity to deal with perceptual complexity. Travers and Alvarado (1970) hypothesized that "a child prefers the most complex presentations that he is able to organize perceptually" (p. 59). This statement must be interpreted carefully, however, for Travers (1969) also found that when highly familiar objects were involved, second graders displayed an ability to recognize pictorial stimuli at a level comparable to that of adults. The familiarity of the depicted items or scenes, as well as the artistic features employed, affect the perceptual complexity of a picture.

Amsden, R.H. Children's preferences in picture story book variables. Journal of Educational Research, 1960, 53, 309-312.

Sixty children from 3 to 5 years of age viewed two sets of ten illustrations. The illustrations within a set varied with respect to color (black

and white or color[s]), intensity of the color (light or saturated shades), and style of drawing (fanciful or realistic). The children saw pairs of illustrations and selected the picture they preferred from each pair. Results indicated that the children's preferences did not differ significantly between the two sets. The children preferred darker shades of color, more colors over fewer colors within a picture, and fanciful pictures (depicting personified objects) over realistic pictures. Black and white photographs were preferred over black and white drawings.

Bamberger, F.E. The effect of the physical make-up of a book upon children's selection. John Hopkins University Studies in Education, No. 4 Baltimore, Maryland: John Hopkins Press, 1922.

First, second, and third graders were told a story up to a certain point, then the children were allowed to examine five editions of books containing the rest of the story. The various editions differed in terms of illustrations. The investigator assumed that preference for an edition indicated illustrative preferences. The books were Cinderella, Sleeping Beauty, Peter Rabbit, Little Black Sambo, and The Night Before Christmas. Analysis indicated that the children preferred color pictures over black and white and preferred saturated color. Pictures containing large central groups were favored as were pictures employing story-telling qualities and humor. No significant difference in preference due to sex was noted.

Bloomer, R.H. Children's preference and responses as related to styles and themes of illustrations. The Elementary School Journal, 1960, 60, 334-360.

This study investigated children's responses to three themes and three styles of illustration. The themes were (a) positive with action in progress, (b) negative with action in progress, and (c) positive without any action. The three styles were line drawing, shaded line drawing, and color line drawing. Fourth, fifth, and sixth-graders (336 subjects) viewed three pictures representing each style and theme. The design balanced the distribution of theme and style. Subjects were asked to indicate which of the pictures they liked best and which of the pictures they liked least. Then each student was asked to write a story to tell what was happening in one of the pictures.

Analysis indicated that the children preferred the color illustrations and disliked the pictures depicting a negative scene. Significantly more children chose to write a story about line drawings than about the shaded or color illustrations; significantly more children wrote stories about the picture depicting a negative event than about the pictures depicting positive events. The quality of the story content was affected more by the picture style than by the theme as stories prompted by the line drawings were more realistic and had an organized beginning and end.

Clegg, L.B. An analysis of the picture illustration preferences of primary grade children (Doctoral dissertation, Texas Technological College, 1968). Dissertation Abstracts, 1968, 29, 1672A. (University Microfilms No. 68-17, 544)

Forty-four matched pictures were developed to test children's preference with respect to intensity of color, artistic style, and characters. The subjects were 450 first, second, and third graders from varied socioeconomic backgrounds. Results indicated that the children preferred saturated color over light tints, realistic portrayal of animals over a stylized portrayal of animals, and portrayal of imaginary animals over realistic portrayal of animals. White and Chicano children preferred illustrations depicting white children over illustrations depicting black children or a mixture of children. Ease in ability to select preferred illustrations increased with age. Children often selected an illustration according to the sex depicted within the picture.

Freeman, G.L. & Freeman, R.S. The child and his picture book. Chicago: Northwestern University Press, 1933.

Sixty nursery school children viewed pairs of pictures depicting an animal and a child (similar subject matter) in differing styles. The picture styles were photograph, black and white drawing, naturally colored drawing, and decorative abstract drawing. Upon presentation of each pair, the children were asked to select the illustration they preferred. Each picture was compared twice with every other picture. Analysis indicated that these subjects preferred color pictures over black and white pictures; they also preferred saturated color. The investigators noted that the children preferred pictures with definite outlines, pictures with some detail, and pictures with a border.

French, J.E. Children's preferences for pictures of varied complexity of pictorial pattern. Elementary School Journal, 1952, 53, 90-95.

Thirteen pairs of illustrations were developed depicting the same scene in a simple and a complex manner. Subjects of the study were 88 elementary school teachers and 696 elementary school children from kindergarten through fifth grade. The subjects were shown each pair and asked to choose the illustration they preferred.

The teachers preferred the complex pictures as, for any pair, at least 78% of the teachers selected the complex illustration, and 62.5% of the teachers always selected the complex illustration. 93% of the teachers selected the more complex pictures. From a sample consisting of 142 first graders, simple illustrations were selected from any pair by at least 74% of the children. Over 30% of the first graders always selected the simple illustration; 98% of the first graders selected more simple illustrations. Within the sample of elementary school children (554 subjects in grades K-5), first and sec-

ond graders preferred the simpler pictures (81% of the first graders; 84% of the second graders), while the fourth and fifth graders preferred the complex pictures. This reversal in preference occurred at the fourth grade.

Hildreth, G.H. Color and picture choices of young children. Journal of Genetic Psychology, 1936, 49, 427-435.

Sixteen color pictures were divided into collections, each consisting of four pictures. Children from 3 to 6 years of age (138 subjects) viewed the collections and selected the picture they preferred. Then each subject was shown the four pictures he had selected and was asked to again select the preferred picture. Analysis indicated that the children chose realistic over impressionistic pictures and preferred pictures portraying actions and pictures depicting animals.

The subjects again viewed the drawing reproduced in either color, black and white, outline, or silhouette form. The color pictures were preferred by the children.

Mellinger, B.E. Children's interests in pictures. Teachers College Contribution to Education, No. 516. New York: Teachers College Press, 1932.

Using a comparison by pairs technique, Mellinger presented 821 children in first, third, and fifth grade pictures balanced with respect to subject matter, picture style, and artistic medium. The pictures depicted three subjects: an elephant, a pine tree, and a girl. Each was presented using a black and white, using a two-color or using a three-color production process. All of the pictures were presented in a realistic and in a conventionalized style. Analysis indicated that color pictures were preferred over black and white and that realistic pictures were preferred over the pictures depicting a conventionalized style.

Rudisill, M. Children's preferences for color versus other qualities in illustrations. Elementary School Journal, 1952, 52, 444-457.

Five types of illustrations were selected: (a) black and white photograph, (b) color photograph, (c) color drawing realistic in form and color, (d) outline drawing realistic in form but unrealistic with respect to color. The same subject matter was depicted in each of the types of illustrations. Approximately 1,200 students from kindergarten through sixth grade were shown pairs of pictures with the pair depicting the same scene in differing types of illustrations; the subjects were asked to choose the picture they preferred from each pair. Each type of illustration was compared to every other type of illustration three times over a six day period.

Analysis indicated that these students preferred the color photograph over the black and white photograph and realistic color drawings over unrealistic color drawings. The realistic color drawings were preferred over the outline drawings; however, the black and white photographs (realistic uncolored) were preferred over the unrealistic color drawings.

Stewig, J.W. Children's picture preferences. Elementary English, 1974, 51, 1012-1013.

The picture variables of color, shape, proportion, detail, and space were investigated in this study with 1,078 school children. The subjects viewed selected slides and indicated their preferences. Analysis of variance revealed no significant difference in the children's selection due to grade level, sex, race, or social class; significant interactions were noted. The older subjects preferred realistic color more than the younger children; significantly more younger children preferred pictures with fewer details involving few three-dimensional cues. No significant differences with respect to shape or proportion selections was noted between the age groups. Children from an upper class background preferred slides with less detail and shallow space significantly more often than middle class children. White subjects preferred pictures with realistic color and flat shapes significantly more often than black students.

Travers, R.M.W. A study of the advantages and disadvantages of using simplified visual presentations in instructional materials. Final Report. USOE Grant No. OEG-1-7070144-5235, 1969. (ERIC Document Reproduction Service No. ED 031 951)

See abstract in preceding section, "Children's Perception of Pictures," pages 29-30.

Travers, R.M.W., & Alvarado, V. The design of pictures for teaching children in elementary school. AV Communication Review, 1970, 18, 47-64.

See abstract in preceding section, "Characteristics of Pictures," page 25.

Waymack, E.H., & Hendrickson, G. "Children's reactions as a basis for teaching picture appreciation. Elementary School Journal, 1932, 33, 268-276.

Fourth, fifth, and sixth graders were presented selected pictures and told to select the pictures they preferred. The subjects were then requested to write a short essay on their selection. Analysis indicated that the children selected their favorites on the basis of color, scenery, and interest in the subjects involved. Pictures which the children could relate in some way with

their previous experiences had considerable appeal.

Whipple, G. Appraisal of the interest appeal of illustrations. The Elementary School Journal, 1953, 53, 262-269.

Six reading textbooks for the fourth grade were selected and, from these texts, 465 illustrations were chosen which presented from one to four colors. From these pictures, six booklets were made each consisting of the selected illustrations from one reader. Subjects (150) with fourth grade reading ability, as measured by the New Stanford Reading Test, were selected; none of the subjects had seen the textbooks. The children were each presented a pair of booklets and told to indicate each picture which they felt would correspond with an interesting story. From his indicated pictures, each subject selected three illustrations and read the three stories associated with those selected illustrations. This procedure was repeated three times; hence each child viewed each of the six textbooks.

Analysis indicated that pictures which depicted a sequence of action were often selected. Color was more appealing if it was realistic. Large pictures were more attractive to the students than were small pictures, particularly if they had a definite center of interest without too many details. Themes dealing with human interest or adventure were preferred over uneventful themes.

Williams, F. An investigation of children's preferences for pictures. The Elementary School Journal, 1924, 25, 119-126.

Fifth, sixth and seventh grade students (939 subjects) visited an art gallery and viewed a selected collection of 63 oil paintings, colored prints, miniatures, tintypes, and daguerreotypes. Each of the children selected the picture they preferred by a secret ballot. Eleven pictures received 82.6% of the votes; of the remaining pictures, 28 were each selected by less than 15 children, and 24 were not selected by any child. The children selected pictures which portrayed familiar places or incidents and, to some extent, had story appeal. Pictures unfamiliar to the subjects but presenting scenes which they had read or heard about were also popular. Large, easily distinguished objects in the foreground characterized the three pictures most often selected by the children. Instruction had little influence on the selection.

VI. Depth Perception in Static Two-Dimensional Pictures

In order to indicate addition or subtraction in dynamic two-dimensional pictures, it is necessary to convey motion of one set toward or away from another set, which may or may not be stationary. In order to do this, many illustrators make use of three-dimensional cues to suggest distance. However, not all three-dimensional cues are readily interpreted by primary school children.

Among the several devices commonly used to indicate depth are: (a) familiar size, (b) linear perspective, and (c) overlap. The familiar size cue indicated distance by drawing the larger of two known objects with smaller dimensions. This convention is often used in conjunction with linear perspective as the farther object is depicted on a higher level than the closer object (sometimes termed the elevation cue), as measured from the base of the drawings, and lines known to be parallel within the object or setting are drawn as converging lines. Overlap refers to the convention of superimposing nearer objects over farther figures, obscuring portions of the figures which are at a distance.

Much of the research concerning depth perception from line drawings has centered around investigations utilizing Hudson's pictorial depth perception test; developed for studies with African subjects. The test consists primarily of line drawings of three figures: a hunter, an antelope, and an elephant. The procedure involves asking the subject to name the depicted figures and to identify which figures are nearer. Hudson (1960) found that all of the subjects of his study had difficulty perceiving depth from the stimuli, the uneducated subjects having particular difficulty. Numerous studies have since been undertaken using Hudson's test with different cultural groups. These studies indicated that children of most cultures provide two-dimensional responses (e.g., Deregwoski, 1968; Mundy-Castle, 1966; Satterly, 1968). At least one study using Hudson's test indicated a possible relationship between the level of formal education and pictorial depth perception (Kilbride; Robbins, & Freeman, 1968).

Many researchers have since suggested that Hudson's results may not be due to the subjects' misperceptions of conventional depth cues, but rather to the nature of the line drawings employed. Their subsequent studies involved variations on Hudson's test by rephrasing the questions, changing the depicted animals, and removing motivational influences. Comparison of the subjects' scores on the revised forms (Omari & Cook, 1972; Omari & MacGinitie, 1974).

In a series of studies at Indiana University, the development of children's ability to utilize size, overlap, aerial perspective, and linear arrangement cues had been under investigation. Oh (1969) showed 20 photographic prints utilizing one depth cue to preschool and elementary school children, asking the subjects to indicate the closest object in each picture. A significant effect due to age was noted as understanding of depth cues progressed from understanding of length cues to development of aerial perspective, overlap and size cues. In a similar study, Baikie (1970) investigated the effect of single depth cues and combinations of cues on the perception of depth by 5 and 6 year olds. He noted recognition of length cues occurred significantly more often than recognition of overlap or size cues and that combinations of cues resulted in more three-dimensional responses. Instruction in utilizing the depth cues of size, overlap, and linear arrangement has also been shown to be effective for 5 and 6 year olds when measured immediately after instruction (Dilawar, 1971).

Other studies have tended to support the research in Indiana in the following sense: Preschool children have difficulty interpreting depth cues, but

increasing age and schooling has significant impact; during the primary grades, children begin to perceive depth in static two-dimensional pictures (Brown, 1969; Jahoda & McGurk, 1974a, 1974b).

Baikie, D.A. The effects of single and combined pictorial cues on the perception of depth by children aged five and six from two socio-economic groups (Doctoral dissertation, Indiana University, 1970). Dissertation Abstracts International, 1971, 32, 1911A. (University Microfilms No. 71-11,.362)

Thirty-five black and white pictures, each depicting three objects, were developed presenting the illusion of depth by the size, overlap, or linear arrangement cues or by combinations of the three cues. The 120 subjects aged 5 to 6 years were shown the pictures in a random order and asked to point to the depicted object "closest" to them. Analysis of variance indicated a significant effect due to age, socioeconomic status, and depth cues. The linear arrangement cue was recognized significantly more than either the size or overlap cues. Depth was interpreted in pictures utilizing a combination of cues significantly more than in pictures presenting a single cue with highest recognition occurring when all three cues were present. A significant interaction of socioeconomic status and recognition of cues and of socioeconomic status, age, and recognition of cues was also noted.

Brown, L.B. The three-dimensional reconstruction of a two-dimensional display. Journal of Genetic Psychology, 1969, 115, 257-262.

A plastic farm set was initially photographed in three arrangements such that the photograph depicted the actual size of the front objects. Subjects, aged from 3 1/2 to 9 years, were shown the photographs and told to arrange the items so that they looked like the photograph. The first photograph had all items clearly visible; the second photograph utilized some overlap cues; the third photograph depicted the overlap cue, eliminating two of the objects from the farm set.

A general developmental trend was noted through five stages: (a) correctly identifying items but random placement (3 1/2-4 years); (b) arrangement of items mirroring against or on the photograph (4-5 years); (c) positioning of a few items determining arrangement of the items near the borders (4 1/2-6 years); (d) good correspondence between items and photographs (6-8 years); and (e) correspondence between items indicating depth perception (6-9 years).

Deregowski, J.B. Difficulties in pictorial depth perception in Africa. British Journal of Psychology, 1968, 59, 195-204.

A construction test was devised which required subjects to build a three-dimensional geometric model using a two-dimensional pictorial guide. Ninety-

six subjects from the Bantu tribes of Africa were administered both the construction test and Hudson's test. Half of the subjects were school children from 7 to 16 years of age and half of the subjects were adults (16-58 years) with schooling equivalent to that of the children. Results indicated a significant proportion of the subjects who gave two-dimensional responses on Hudson's test could build the geometric model.

Dilawar, M.E. The effects of an instructional session on the perception of single depth cues in two-dimensional pictorial materials by children aged five and six (Doctoral dissertation, Indiana University, 1970). Dissertation Abstracts International, 1971, 31, 4551-4552 A. (University Microfilms No. 71-6, 845)

A collection of transparencies was developed for use during instruction of the interpretation of the single depth cues of size, overlap, and linear arrangement. Subjects were 112 five and six year olds. Half of the subjects were randomly assigned to a 20 minute instructional period utilizing the transparencies with individual testing immediately after the instruction. Each instructional group consisted of five students. The remaining 56 students viewed the transparencies without instruction. They too were individually tested immediately after viewing the materials. The test involved identifying the "closest" object from each of 15 different pictures.

Analysis of variance procedures indicated a significant effect due to instruction. With respect to age, no significant difference was noted between the 5 year olds who received instruction and the 6 year olds who did not receive instruction; among only the children who did not receive instruction, the 6 year olds utilized depth cues significantly more than did the 5 year olds. Five year olds in the instructional group had a significantly higher perception of size and overlap cues than the 5 year olds without instruction. For the 6 year olds, instruction resulted in a significantly higher perception of the size cue.

Hudson, W. Pictorial depth perception in subcultural groups in Africa. Journal of Social Psychology, 1960, 52, 183-208.

A pictorial depth perception test was developed; test materials consisted of line drawings with the three main characters of a hunter, an antelope, and an elephant. The procedure involved asking the subjects to interpret the pictures, identifying which of the three figures was nearer. The test was administered to 11 different samples of subjects in South Africa, ranging from illiterate adult mine workers to white sixth grade children. Results indicated that those subjects whose background favored exposure to pictures scored higher on the test; however, all of the subjects had difficulty perceiving depth from the pictures.

Jahoda, G. & McGurk, H. Development of pictorial depth perception: Cross-cultural replications. Child Development, 1974a, 45, 1042-1047.

Subjects from Scotland, Hong Kong, and Rhodesia were shown a color picture of a landscape involving either an elevation cue, a single lenear perspective cue, or a double linear perspective cue. In each picture there were two figures (a girl and a woman, two women, or two children) in a foreground or background position. Subjects were shown the picture and told to place two wooden figures, from a collection of two large and two small figures, on a green rectangular board as shown by the picture.

Two responses were scored for each subject--a size response and a position response. In all of the countries, size response scores differed significantly with respect to depth cues with fewest errors occurring when an adult was pictured in the foreground and a child depicted in the background. In Scotland, size response scores differed significantly with respect to age while in Rhodesia a significant difference in size response scores was noted due to education level. Spatial responses scores differed significantly with respect to age and with respect to depth cues in Scotland, Rhodesia, and urban Hong Kong. Pictures depicting linear perspective cues had significantly fewer correct spatial responses than the pictures with elevation cues for these subjects. Increasing age and schooling had an effect on spatial responses.

Jahoda, G. & McGurk, H. Pictorial depth perception: A developmental study. British Journal of Psychology, 1974 b, 65, 141-149.

Sixty subjects from four age groups (4-4 1/2 years, 6-6 1/2 years, 8-8 1/2 years, 10-10 1/2 years) in Scotland were individually presented a color landscape picture depicting two characters. The depicted figures were either two girls. two women, or a girl and a woman; the picture presented a woman in the background as the same height as a girl in the foreground. The pictures employed either an elevation cue, a linear perspective cue, or a combination of elevation linear perspective and size cues. The testing procedure involved individually presenting the subjects with the pictures and directing the subjects to place wooden figures (from a collection of two child-size and two adult-size figures) on a rectangular board as indicated by the pictures. Both size and spatial responses were recorded.

Analysis indicated a significant difference in size response scores due to age and depth cues. The 4 and 6 year old children had significantly lower scores than the 8 and 10 year olds. The size response scores for the pictures with a combination of cues were significantly higher than for the pictures with only the linear perspective cue, which in turn was associated with significantly higher scores than the pictures with only elevation cues. Age and depth cues were also associated with a significant difference in spatial response scores. Again the younger children had significantly lower scores than the older children; also the 10 year olds scored significantly higher than the 8 year olds. As judged by the spatial response scores, the combination of depth cues led to less accurate depth perception than either of the single cues; the pictures with only linear perspective cues were associated with significantly more cor-

rect spatial responses than pictures with only the elevation cue.

Kilbride, P.L., Robbins, M.C., & Freeman, R.B., Jr. Pictorial depth perception and education among Baganda school children. Perceptual and Motor Skills, 1968, 26, 1116-1118.

Using Hudson't test, the pictorial depth perception of 216 rural school children from 4 to 20 years of age in Uganda was measured. Chi-square analysis revealed a significant positive relationship between pictorial depth perception and the level of formal education. Subjects with less education were able to perceive depth within pictures utilizing only the overlap cue significantly more often than in pictures using only size cues.

Mundy-Castle, A.C. Pictorial depth perception in Ghanian children. International Journal of Psychology, 1966, 1, 288-300.

The pictorial depth perception of 122 children from 5 to 10 years of age was measured using pictures from Hudson's test. Results indicated that the subjects recognized familiar figures but did not perceive abstract relationships. Only one student (age 8) gave three-dimensional responses to all of the pictures.

Oh, C.Y. A study of the development of children's ability to perceive depth in static two-dimensional pictures (Doctoral dissertation, Indiana University, 1968). Dissertation Abstracts, 1969, 29, 3470B. (University Microfilms No. 69-4, 793)

A collection of 20 photographs each depicting three objects was developed portraying the depth cues of size, overlap, linear arrangement, or aerial perspective. Each of the 180 subjects (5 to 11 years of age) was shown the pictures and, for each photograph, asked to identify the object closest to them. Analysis indicated a significant difference in response due to age, implying a developmental trend: From age 3 to 5, and understanding of linear cues develops; overlap size and aerial perspective cues develop from age 5 to 6; and, by age 9, depth is perceived equally well through all four cues.

Omari, I.M., and Cook, H. Differential cognitive cues in pictorial depth perception. Journal of Crosscultural Psychology, 1972, 3, 321-325.

In Hudson's pictorial depth perception test, the subjects are shown drawings and asked questions of the form, "Which is nearer the man, the ___ or the ___?" Citing evidence to suggest that questions which substituted the word "looks" for "is," "farther" for "nearer," or "you" for "man," may be more readi-

ly interpreted by children, the investigators developed alternate forms of questions for Hudson's test. Subjects were 40 third graders who were assigned to one of eight groups using the varied forms of questions. Analysis of variance indicated that students who were administered the test using the term "farther" had significantly higher scores than subjects who answered questions concerning "nearer" items.

Omari, I.M., and MacGinitie, W.H. Some pictorial artifacts in studies of African children's pictorial depth perception. Child Development, 1974, 45, 535-539.

A revised version of Hudson's test was developed which changed the depicted animals in the pictures to a cow and a goat, rather than an antelope and an elephant, and removed motivational inferences. Subjects were first, third, fifth, and seventh graders from three schools in Tanzania. Half of the students were administered the revised form of the test. Analysis indicated a significant difference in responses due to school, grade, and test version with a significant interaction between school and grade and between grade and test version. The first and third graders found both forms of the test to be difficult, but the revised version yielded consistently higher scores. On the revised version, a significant increase in scores occurred with an increase in grade level; this was not the case with Hudson's test.

Satterly, D. Perceptual, representational and conceptual characteristics of primary school children. British Journal of Educational Psychology, 1968, 38, 78-82.

Two hundred subjects from ages 7 through 11 were administered a battery of 15 tests on arithmetic computation, vocabulary, reading, visual and haptic perceptual tasks, drawing, and spatial perception. Hudson's pictorial depth perception test was one of the tests administered. Results indicated that younger children have two-dimensional responses to Hudson's test. Drawings to represent space progressed through five stages: (a) no orderly arrangement of object, (b) orderly arrangement in a horizontal plane bound to a base line, (c) attempt at the illustration of depth using the overlap cue, (d) linear perspective inconsistently represented, and (e) depth and space depicted.

VII. The Effects of Pictures on Reading

The influence of pictures on learning within the elementary school curriculum has been investigated within two categories of reading, learning to read words and learning to read passages for comprehension. Studies which consider the effect of pictures as an adjunct to the understanding of the written or oral text may supply insight as to the effect of pictures accompanying number sentences within elementary mathematics lessons as in both situations the pictures are intended to aid the student in interpreting accompanying symbolic material. These studies may also suggest investigations concerning the role

of pictures in the learning of elementary school mathematics.

Studies by Harris (1968) and Samuels (1970) under experimental conditions noted that young children acquire sight vocabulary faster under a word-only condition than when pictures and words were used simultaneously. Samuels also conducted a similar study within a first grade classroom where 26 students received passages to read with an accompanying illustration and 26 other students received the same passage without an illustration. After classroom reading instruction, a posttest was administered. Results indicated no significant difference between the two conditions for better readers. However, poorer readers in the no-picture condition learned significantly more words than the poorer readers in the picture condition; the presence of an illustration seemed to interfere with the acquisition of sight vocabulary among poorer readers.

Samuels' study under experimental conditions taught the students to read a list of four unrelated words. King and Muehl (1965) also investigated the influence of pictures on learning sight vocabulary. They found, as did Samuels, that beginning readers who were taught to read a list of four unrelated words using only printed word cards were more successful than were students who were taught to read the words when pictures were present. However, they noted the opposite trend when the subjects were asked to read a list of similar words. Teaching methods involving picture-word cards were more effective for learning to read similar words than was instruction using only printed word cards.

Miller (1938a) and Weintraub (1960) investigated the effect of pictures in basal readers on comprehension by primary school children. Miller matched first through third graders within their classrooms with respect to reading test scores. Half of the students in each classroom received the adapted basal reader while the other students received the same reader with all the illustrations covered. After one semester of instruction, a reading comprehension test and an achievement test were administered. Analysis indicated no significant difference in scores on either test between the picture and the no-picture groups. However, these results must be interpreted in terms of Miller's comprehension test which required the children to select written words or phrases when spoken by the teacher, to complete sentences, to identify extraneous words, and to sequence events. Weintraub constructed a multiple-choice examination to measure second graders' comprehension of three stories from their basal reader. The students read the stories with or without an accompanying picture or viewed only the illustrations without the text. His data indicated that students in the no-picture condition had higher comprehension scores.

Strang (1941) had fourth through sixth graders read six passages (half were illustrated, half were not) and, after reading each passage, answer four questions designed to measure comprehension. He found that individual comprehension scores on the illustrated passages were higher than on the non-illustrated passages. Unfortunately, Strang did not control for order of presentation effects; the illustrated condition always succeeded the non-illustrated condition. In a later series of studies, Vernon (1953, 1954) found in contrast to Strang's results, that illustrations had little influence on the recall or comprehension of written passages.

Koenke (1968) investigated the relationship between a picture and comprehension of the main idea of a paragraph by third and sixth graders. His treatments varied the presence of an accompanying picture, as well as the type of directions concerning the presence of the picture. Neither the presence of the pictures nor explicit directions referring to the pictures had a significant effect on the students' ability to state the paragraph's main idea. In a related study, again with third and sixth grade subjects, Koenke and Otto (1969) investigated whether pictures referring to the main idea of the paragraph or pictures relating to a specific section of the paragraph influenced students' comprehension of the main idea of a paragraph. Analysis indicated that the presence of an accompanying picture yielded significantly different comprehension scores for the sixth graders, although the type of picture had no significant effect. No significant differences were noted for the third graders; however, the third graders were all reading paragraphs assessed at the fifth or sixth grade reading level.

In order to investigate the possible interaction between children's reading ability and the mode of presentation (printed words or pictures), Levin (1973) presented two stories to fourth graders classified by their level of reading achievement. The students received either picture sequences or written passages, (visual imagery instructions were also given to some of the subjects) and then completed a reading comprehension test. Results did not indicate a significant interaction between reading level and mode of presentation nor was a significant difference in comprehension noted between the picture and printed story presentations.

A later study by Rohwer and Matz (1975) investigated the effect of pictures and print on learning orally presented prose as well as the influence of socioeconomic status (SES). Analysis of the results of a true-false test indicated that the accompanying picture presentation resulted in higher comprehension scores than the accompanying printed presentation. A significant difference due to SES and a significant interaction between SES and presentation mode was also found. No significant difference in scores between low and high SES subjects was noted within the picture presentation mode; however, within the printed presentation treatment, subjects with a high SES rank averaged 82% on comprehension whereas low SES subjects averaged 57% correct--almost at chance level.

One further series of studies has investigated whether the construction of pictures to illustrate a story by children or the observation of the construction of such pictures will facilitate the learning of written passages. Lesgold, Levin, Shimron, and Guttman (1975) found in their initial study that constructing pictures to depict the story which had just been read did not result in an increase of recall of the story by first graders. In fact the subjects in the picture-construction treatment were not as successful as the control subjects on the recall test. Hypothesizing that this seeming picture interference was due either to the amount of cutout material for constructing the pictures or to the experimental procedures, which prevented the subjects from constructing their picture until the entire story had been read, the researchers systematically varied these factors in follow-up studies. Analysis of the results of this series of experiments indicated that an illustration activity assisted comprehension of written passages for first graders when

the choice of items for the illustration was not left to the child.

Harris, L.A. A study of the rate of acquisition and retention of interest-loaded words by low socioeconomic kindergarten children (Doctoral dissertation, University of Minnesota, 1967). Dissertation Abstracts, 1968, 28, 3556A. (University Microfilms No. 68-1, 627).

Two word lists were constructed consisting of either four words judged as being interest-loaded for girls or four words judged as being interest-loaded for boys. A word was assessed as being interest-loaded for one sex if it was identified as being appealing by at least 80% of one sex and less than 25% of the other sex. Kindergarten children (240 subjects) were individually presented four words to learn under one of two conditions. In the visual-auditory condition, the children saw the words, heard them read by an experimenter, and repeated the words; in the visual-visual-auditory condition, the children similarly heard and repeated the words only they saw picture-word cards. One day after attaining mastery of the words, the word cards were presented to the children for identification. Analysis indicated that the method of presentation affected initial acquisition, as the word-only condition had higher rates of acquisition; however, retention was independent of sex, word appeal, and presentation mode effects.

King, E., & Muehl, S. Different sensory cues as aids in beginning reading. Reading Teacher, 1965, 19, 163-168.

Kindergarten children (210 subjects) were taught to read a list of four similar words (doll, ball, bowl, bell) or a list of four dissimilar words (gate, drum, nest, fork) under one of five instructional conditions. The conditions were: picture-word cards only, word cards with an experimenter reading the words to the subject, picture-word cards with experimenter reading the words, word cards with an experimenter reading the words and the subject repeating the words, picture-word cards with an experimenter reading the words and the subject repeating the words.

Analysis indicated that similar words were more difficult to learn as the mean number of correct responses for similar words was significantly less than the mean number of correct responses for dissimilar words. A significant interaction between word type and learning rate was noted as dissimilar words were learned at a faster rate. Similar words were learned more effectively with picture-word cards; dissimilar words were learned more effectively with word cards.

Koenke, K. The effects of a content-relevant picture on the comprehension of the main idea of a paragraph (Technical Report No. 86). Madison, Wisconsin: University of Wisconsin, Wisconsin Research and Development

Center for Cognitive Learning and the Laboratory for Research in Basic Skills, June, 1968. (ERIC Document Reproduction Service No. ED 024 540)

Three passages, each consisting of four sentences, were authored and then rewritten to be suitable for the first, third, and sixth grade reading levels. An accompanying picture was developed for each passage. The picture-passage relationships were similar in nature; however, the passages did refer to different topics. Four treatments were compared: paragraph only, paragraph and picture without explicit directions to refer to the picture, paragraph and picture with minimal directions to look at the pictures, and paragraph and pictures with directions to study the picture. The 192 third and sixth grade subjects each read three passages. Half of the subjects in each treatment read passages which were assessed as being at the first grade level while the other subjects read passages constructed for their grade level. After reading each passage, the students were asked to state verbally the main idea of the paragraph. Analysis of the results indicated that neither grade, sex, nor the presence of pictures had a significant effect. No significant difference in responses was noted between the groups with specific directions referring to the picture and the picture-paragraph group without specific direction concerning the picture.

Koenke, K., & Otto, W. Contribution of pictures to children's comprehension of the main idea in reading. Psychology in the Schools, 1969, 6, 298-302.

Three reading passages were developed each consisting of 15 or 17 sentences at either the fifth or sixth grade level. For each passage two black and white pictures were developed; one of the pictures conveyed the main idea of the passage, and the other picture depicted a specific aspect of the passage. Subjects were 180 third and sixth graders. Treatments were as follows: passage only, passage and specific content picture, passage and main idea picture. After reading each passage, the students were asked to state the main idea of the passage. Analysis indicated that for sixth graders, the presence of pictures had a significant effect on responses; no significant difference due to the presence of pictures was noted for the third graders. However, the younger students in all three treatments were reported as having difficulty reading passages above their grade level. The type of picture had no significant influence on the responses of either the third or sixth graders.

Lesgold, A.M., Levin, J.R., Shimron, J., & Guttman, J. Strategies in reading comprehension IV: Pictures and young children's learning from oral prose (Technical Report No. 328). Madison, Wisconsin: University of Wisconsin, Wisconsin Research and Development Center for Cognitive Learning, February, 1975.

This report concerns a series of four studies investigating the possible relationship between learning written passages and constructing or observing the construction of pictures to depict the event described in the passages.

In the first study, 24 first graders were orally read five single-episode stories suitable for the age. They were told prior to the reading that they would later be asked to recall what had happened in the stories. Half of the subjects were presented a collection of cutout materials after each story and were given two minutes in which to construct a picture to illustrate the story. The remaining subjects were given a control task during this two minute interval. After each of these intervals, the subjects were administered the recall task before hearing the next story. A scoring procedure was devised to rate the exactness of recall and the appropriate placement of the cutouts. Analysis indicated that the control group recalled significantly more propositions (32%) than the picture construction group (21%). There was a positive relationship between verbal recall and picture adequacy; however, less than half of the constructed illustrations conveyed the main idea of the passage.

A follow-up study was then conducted with 48 first graders. In this study, half of the subjects in the picture treatment constructed an illustration after each sentence of a passage; the remainder of the picture group constructed their illustrations after hearing the entire story. Similarly, the timing of the control tasks varied. Also the children in the picture treatment received only those cutouts necessary to construct an illustration for a given sentence or passage. After each recall task, the children were also asked a question about each sentence of the paragraph. Analysis indicated that timing had no effect on the responses to the recall or the short-answer questions; however, scores were significantly higher for subjects who performed the illustration activities. Almost no inadequate illustrations were constructed.

In a third related experiment, 24 first graders either observed an adult construct pictures after the adult read aloud each sentence of a passage or the first graders constructed their own illustrations. No significant difference in recall was noted between the groups.

A final study randomly assigned 36 first graders to three conditions: picture construction by subject after each story, observation of picture construction after each story, and control. Background and cutout forms for all three stories were available; hence the picture construction group had to select appropriate figures as well as construct illustrations. Analysis of the results indicated no significant difference between the groups on free recall responses, but the children in the picture observation treatment scored significantly higher on the short answer questions than either of the other treatments.

Levin, J.R. Inducing comprehension in poor readers: A test of a recent model. Journal of Educational Psychology, 1973, 65, 19-24.

Two stories, each consisting of 12 sentences, were authored. For each sentence of the passages, a cartoonlike color drawing was drafted. Subjects were 54 fourth graders classified by their achievement on a standardized reading test and their teacher's ranking of their classroom reading achievement. One-third of the subjects viewed the two sequences of drawings. The remainder

of the children read the printed stories; half of these subjects also received visual imagery instructions. Thirteen questions concerning the content of each story were then administered. Results indicated that "good" readers scored significantly higher on the comprehension test than did "poor" readers, but that there was not a significant interaction between reading level and mode of presentation. No significant difference in comprehension was noted between the picture and printed story presentations; however, those subjects who received imagery instructions had significantly higher scores than those children who read the passages without imagery instructions.

Miller, W.A. Reading with and without pictures. Elementary School Journal, 1938a, 39, 676-682.

First, second, and third graders (600 subjects) in three elementary schools were administered a reading test and, on the basis of their scores, matched within their classes. Half of the children in each grade level had basal readers with all of the pictures covered; the remaining students had the same reading text with the illustrations visible. After one semester, a standardized reading achievement test and a comprehension test developed by the investigator was administered. Analysis of the test scores did not indicate a significant difference between the two reading conditions. However, the comprehension test was unique as the procedure required the children:

> To choose, from a group of words, a word spoken by the teacher; to select a phrase from two phrases when one was spoken by the teacher; to cross out an extraneous word from a group of three words; to complete a sentence after reading a paragraph; and to put in proper sequence the happening recorded in a paragraph to be read. (p. 678)

Rohwer, W.D., Jr., & Matz, R. Improving aural comprehension in white and in black children. Journal of Experimental Child Psychology, 1975, 19, 23-36.

Three passages, judged to be at a level suitable for all 128 fourth grade subjects, were orally presented via an audiotape. The subjects simultaneously viewed a sequence of 16 slides presenting either printed sentences or pictures. Each of these slides depicted prior information from the passage plus new information just being revealed in the oral presentation; hence, the final slide presented the total passage in either a printed or a picture form. After each passage, the subjects were individually presented with 12 statements to be judged as true or false in terms of the passage. This testing occurred under two conditions; in one condition the passage was available for referral, in the other the passage was not present.

Analysis indicated that the accompanying picture treatment resulted in significantly higher scores than did the printed presentation for both high and low SES groups. No significant effect due to testing conditions was found. A significant effect due to SES and an interrelationship between SES and pre-

sentation mode was noted. White subjects ranked as within a high SES averaged 81% correct. However, within the printed presentation treatment, white subjects ranked with a high SES averaged 82% on the comprehension whereas black subjects ranked as within a low SES averaged approximately 57% correct.

Samuels, S.J. Effects of pictures on learning to read, comprehension, and attitudes. Review of Educational Research, 1970, 40, 397-407.

This review of literature presents results of several studies investigating the effects of pictures as aids within reading instructions. Samuels' own study dealing with kindergarten children and first graders is also summarized. Thirty kindergarteners were randomly assigned to two groups where they learned to read four words (boy, bed, man, car). One group was instructed using only the printed words; the other group was instructed through the use of picture-word cards. During the testing situation, the children were asked to read the words when no picture was present. The no picture group excelled. A similar study was conducted within a first grade classroom using 26 matched pairs of students with seven months of reading instruction. Half of the subjects received a booklet containing a passage with an illustration; the remaining students received a booklet containing only the passage. A posttest after classroom instruction did not result in significantly different scores between the two groups for better readers. However, among poorer readers, the no-picture group had learned significantly more words than the picture-word group.

Strang, A.M. A study of gains and losses in concepts as indicated by pupils' reading scores after the addition of illustrations to reading material. Unpublished doctoral dissertation, Temple University, 1941.

Eighteen original stories were drafted, six stories each at the fourth, fifth, and sixth grade reading level. For each story, five multiple-choice questions were also drafted to assess reading comprehension. A photograph or a shaded black and white line drawing to illustrate one aspect of each story was constructed. The fourth, fifth and sixth grade subjects were matched according to reading ability. Each of the students read three of the stories without an illustration and, several weeks later, read the three remaining stories with an accompanying illustration. The presence of a picture tended to increase the time necessary to complete the tests for brighter students while decreasing the time for slower students. The individual comprehension scores on illustrated passages were usually higher than on the non-illustrated passages.

Vernon, M.D. The instruction of children by pictorial illustration. British Journal of Educational Psychology, 1954, 24, 171-179.

Two passages were drafted; one of the passages had pictures interleaved

with the text, and the other passage had no illustrations. Twenty-four subjects, aged 11 to 12 years, were individually asked six general questions after reading. As determined by the responses, the pictures had no effect on the children's understanding. The passages involved may have been difficult for the subjects to assimilate.

In a later study, 60 subjects (10 to 12 years of age) listened to the reading of three passages while viewing one of three types of illustration presentations. Either 10 individual pictures were presented at the appropriate point during the reading or else three or four drawings or photographs were present during the entire reading. No significant difference due to illustration type was noted on either comprehension or recall of the verbal material.

Vernon, M.D. The value of pictorial illustration. British Journal of Educational Psychology, 1953, 23, 180-187.

Thirty-eight subjects from 16 to 18 years of age each read two passages. The first passage was written in a popular style with four accompanying photographs; the second reading was scientific in nature with graphs. After a 10 minute interval, a recall and comprehension test was administered. This procedure was repeated with 24 other subjects from 15 to 16 years of age. Only some of these subjects received the passages without illustrations. No significant difference in scores due to illustrations was indicated.

Weintraub, S. The effect of pictures on the comprehension of a second grade basal reader (Doctoral dissertation, University of Illinois at Urbana, 1960). Dissertation Abstracts, 1960, 21, 1428A (University Microfilms No. 60-4, 016)

Three classes of second graders read stories from their basal readers under one of three treatments: pictures covered; picture only, text covered; text and pictures intact. After reading, the subjects were administered a multiple-choice test to measure their comprehension. Data revealed that the text only group had significantly higher comprehension scores than either the picture only or text and picture group.

VIII. Pictures and Mathematical Problems

Very little research concerning the effect of pictures on the learning of primary mathematics has been conducted. One study concerning the possible relationship between first grade children's ability to interpret mathematical pictures as a story and their ability to describe the pictures by a number sentence has been located. Other research reports concerning pictures and mathematics learning have dealt not with primary mathematics, but with the effect of pictorial representations on students' ability to solve typical ninth grade algebra word problems.

In 1971, Sherrill investigated the effects of varying presentations of mathematical word problems upon the problem solving ability of tenth graders. He developed three forms of a test: one form provided only written problems; one form provided written problems with an accurate illustration for each problem; and the third form provided written problems with inaccurate illustrations. Analysis of the results indicated that written problems with accurate pictures led to higher scores than written problems alone, which were superior to written problems in conjunction with distorted pictures. However, a significant correlation between problem solving ability and IQ, reading level, and previous grades in mathematics was also noted and may limit the extent to which this ranking of problem presentation may be generalized.

A later study by Kulm, Lewis, Omari, and Cook (1973) investigated the relationship between aptitude and methods of problem presentation. Ninth grade subjects were randomly assigned to one of five presentations: textbook problems, student generated problems, pictorial problems, textbook problems with pictures, and student generated problems with pictures. Each condition presented 10 problems varying only the method of presentation. Analysis revealed a significant correlation between IQ and problem solving ability among the methods of presentation. Students within the low IQ (below 110) were able to identify and use the correct method with written textbook problems significantly more than with any of the presentations involving pictures; textbook problems with pictures were significantly less effective than any of the other presentations. No significant effect due to problem presentation was noted for the medium or high IQ groups in terms of identification and use of correct problem solving methods.

In 1960, two Soviet studies investigating the influence of pictures and diagrams on arithmetic problem solving were published. The problems used in these studies are typical of the problems in American first-year algebra textbooks, such as mixture problems or rate problems. However, the Soviet mathematics curriculum includes these problems during the first five or six years of schooling to be solved without the use of algebra.

Botsmanova (1960a) conducted an investigation to assess the effectiveness of three types of pictorial aids on problem solving. The pictures were classified as object-illustrative pictures (no mathematical structure), object-analytical pictures (mathematical structure portrayed), or abstract spatial diagrams. She assumed that if a picture was used in the problem solving process, the student should be able to reproduce or describe the picture after solving the problem. First through fourth graders were given a problem with an accompanying picture to solve. Analysis of the data revealed that many students were able to reproduce adequately the analytic pictures, with a lower percentage of students able to recollect illustrative pictures. A related study by Botsmanova indicated that most of the second, third and fourth graders sampled solved problems presented with an analytic picture in a shorter time than problems with illustrative pictures.

A second investigation by Botsmanova (1960b) considered the role of graphic diagrams in problem solving. She found that students who received problem solving instruction involving the use of graphic diagrams were more successful at problem solving than were students without specific problem solving instruc-

tion or students whose problem solving instruction did not consider graphic diagrams.

The students who participated in these Soviet studies were first through fourth graders (approximately 8 to 11 years old), but their mathematics curriculum was not the elementary mathematics curriculum used in the United States. Results of these studies should not be generalized to the teaching of primary school mathematics in America.

A study using illustrations derived from American first grade mathematics textbooks was conducted by Campbell (1976). This investigation considered whether there was a relationship between first graders' ability to tell a story about a dynamic picture or sequence of three dynamic pictures and their ability to describe the picture(s) by a number sentence. The artistic variables characterizing the pictures were controlled. Statistical analysis revealed that neither drawing style nor the number of pictures had a significant effect on either the level of assimilation within the stories, the perception of motion, or the number sentence responses. A significantly higher level of number sentence responses were given by students who selected a number sentence card than by students who write number sentences. Also, initially viewing and interpreting sequences provided a learning experience to significantly affect the interpretation of single pictures. No educationally significant correlation was noted between story response scores and either the number sentence scores or the motion perception scores.

Botsmanova, M.E. [The forms of pictorial visual aids in instruction in arithmetic problem solving]. In J.W. Teller (Trans.) & J. Kilpatrick & I. Wirszup (Eds.), Soviet studies in the psychology of learning and teaching mathematics (Vol. 6). Pasadena, California: A.C. Vroman, 1972. (Reprinted from Reports [Doklady] of the Academy of Pedagogical Sciences of the RSFSR, 1960a, 5.)

Three studies were conducted comparing the effectiveness of three forms of illustrations for problem solving. The forms were:

(a) Object-illustrative pictures which portrayed the objects reflected in the problem, but did not reflect the mathematical structure of the problem.

(b) Object-analytical pictures which portrayed the objects mentioned in the problem and reflected the mathematical structure of the problem.

(c) Abstract spatial diagrams which portrayed numerical relationships.

In the first study 137 students (grades 1-4) were presented with a problem and an analytic or an illustrative picture. After solving the problem, the subjects were asked to reproduce the picture. Illustrative pictures were reproduced by a lower percentage of students than were the analytic pictures. Often

the children's reproductions presented analytic pictures in a more simplified form.

Forty-eight students in second through fourth grade were given problems to solve with analytic or illustrative pictures. At first, most of the students did not refer to the pictures but, as the students continued working on the problem, the analytic pictures were re-examined unlike the illustrative pictures. The problems with analytic pictures were solved in a shorter time than the illustrated problems.

A third study compared the use of object-analytical pictures and graphic diagrams. Twelve third and fourth graders were asked to solve two problems aloud; the problems were balanced with respect to accompanying picture type. No difference was noted as most of the students had difficulty solving the problems.

Botsmanova, M. [The role of graphic analysis in solving arithmetic problems.] In J.W. Teller (Trans.) & J. Kilpatrick & I. Wirszup (Eds.), Soviet studies in the psychology of learning and teaching mathematics (Vol. 6). Pasadena, California: A.C. Vroman, 1972. (Reprinted from Reports [Doklady] of the Academy of Pedagogical Sciences of the RSFSR, 1960b, 6.)

Twelve third graders were selected as subjects for this study. Four of the subjects had 10 experimental problem solving lessons teaching the use of graphic diagrams over a three month period. Four other subjects also had 10 problem solving sessions without graphic diagrams. These students formed the first control group. The remaining four students had the usual classroom instruction; they were designated as the second control group.

After the instructional period, the 12 students were given three problems to solve; if their solution was incorrect they were instructed to try again until it was correct. The first problem did not have a diagram but the subjects were given a hint to draw. The second problem also had no diagram and no hint to construct a diagram was given. The third problem was presented with a diagram. All of the subjects in the experimental treatment constructed diagrams for the first two problems; each of these students was able to eventually solve the three problems. None of the students in the control group were able to solve the first problem despite repeated attempts. The second problem was solved correctly by five of the control students, and the third problem was solved by four of the control students.

Campbell, P.J. The role of pictures in first grade children's perception of mathematical relationships. Unpublished doctoral dissertation, The Florida State University, 1976.

This study investigated the possible relationship between children's ability to tell a story about a picture and their ability to describe the picture by

a number sentence. Further, the effects of the form of a drawing (realistic versus stylistic), the number of pictures (single pictures, sequences of three pictures, or a combination of single pictures and sequences), and response condition (choosing a number sentence versus writing a number sentence) on first graders' interpretation of mathematical pictures were studied. Ninety-six first graders were individually presented a set of 10 pictures, 10 sequences, or 5 pictures and 5 sequences and, for each illustration, asked to tell a story that went with the picture(s). The subjects were then requested to either write or choose a number sentence for that picture or sequence.

Analysis indicated that neither drawing style nor the number of pictures had a significant effect on the level of assimilation within the stories, the perception of motion, or the number sentence responses. Students who chose number sentences had significantly higher number sentence ratings than students who wrote number sentences. Initially viewing and interpreting sequences did provide a learning experience to significantly affect the interpretation of single pictures. No educationally significant correlations were noted between the story response scores and the number sentence scores, the motion perception scores, or the KeyMath scores.

Kulm, G., Lewis, J.F., Omari, L. & Cook, H. The effectiveness of textbook, student generated, and pictorial versions of presenting mathematical problems. Paper presented at the annual meeting of the American Educational Research Association, Chicago, Illinois, April, 1972. (ERIC Document Reproduction Service No. ED 062 139)

Ten word problems from algebra and pre-algebra textbooks were selected. These problems were termed the textbook problems. Pictorial versions of these problems were then constructed with minimal verbal content. Six algebra students were given the pictorial versions and asked to construct their own word problems based on the pictures. These were termed the student generated problems. Using these three sets of problems, five problem presentations were devised: (a) textbook problems (b) student generated problems, (c) pictorial problems, (d) textbook problems with pictures, (e) student generated problems with pictures.

Ninth graders (116 subjects) were randomly assigned to one of the five presentations. The students saw each problem for one minute; during that time they could take any notes they needed. Then the problem was removed, and the students had three minutes to solve the problem before the next problem was presented. Analysis indicated a significant correlation between IQ and identification and use of a correct problem solving strategy. Low IQ students (below 110) had significantly better method scores on the textbook problems than on any of the presentations involving pictures. The textbook problem with picture presentations was significantly less effective than any of the other presentations. Medium (110-119) and high (above 119) IQ groups made significantly more sketches than the low IQ group. In terms of identification and use of correct method, no significant effect due to problem presentation was noted for the medium or high IQ groups.

Sherrill, J.M. The effects of differing presentations of mathematical word problems upon the achievement of tenth grade students (Doctoral dissertation, The University of Texas at Austin, 1970). Dissertation Abstracts International, 1971, 31, 3427A. (University Microfilms No. 71-00, 191)

Using selected mathematics word problems from tenth grade mathematics texts and from the Y- and Z- Population Test Batteries of the National Longitudinal Study of Mathematical Abilities, a word problem test was constructed. Three forms of the test were prepared and administered to three samples of tenth graders: written word problems only (114 subjects); written word problems with accurate pictorial representations (96 subjects); and written word problems with distorted, inaccurate pictorial representations (112 subjects). Analysis of variance indicated that success in problem solving was affected by the method of presentation with an apparent ranking of written problems with accurate pictures over written problems alone over written problems with inaccurate pictures. However, IQ, reading ability, and previous mathematics grades also influenced problem solving.

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